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[OFFICIAL NOTICE.]

Third Annual Meeting, Michigan Gas Association.

SAGINAW, MICH., Jan. 20, 1896.

The third annual meeting of the Michigan Gas Association will be held on Wednesday, the 19th of February, at the Hibbard House, Jackson, Mich.

The morning session will be called to order at 9 o'clock, in the parlors of the hotel, and everything possible will be done for the comfort of the visitors.

The Association extends a most cordial invitation to any officer or employee of any gas company, and to representatives of firms dealing in supplies, to meet with it at this time, and to put in application for membership.

It would be advisable to engage rooms in advance; rates will be $2, $2.50 and $3 per day. It is requested that members be on hand promptly.

As the titles of all papers have not as yet been received, the publication of the list is deferred until later. HENRY H. HYDE, Sec'y.

[OFFICIAL NOTICE.]

February Meeting, Society of Gas Lighting.

OFFICE OF THE SECRETARY, Jan. 23, 1896.

The February meeting of the Society of Gas Lighting will be held in the Arena, No. 39 West 31st street, New York City, on Thursday, Feb. 13, at 3 P.M. FRED. S. BENSON, Sec'y.

[OFFICIAL NOTICE.]

Twenty-sixth Annual Meeting of the New England Association of Gas Engineers.

OFFICE OF THE SECRETARY, LYNN, MASS., Jan. 29, 1896.

The twenty-sixth annual meeting of the New England Association of Gas Engineers will be held at Young's Hotel, Boston, on Thursday and Friday, February 20 and 21, 1896.

The meeting will be called to order at 10 o'clock A.M., Thursday, February 20.

During the meeting the following papers will be read:

"Development of Candle Power," by Mr. Walter S. Allen, Boston, Mass.

"Some Notes on Photometry," by Mr. C. W. Hinman, Boston, Mass.

"Should Gas Holders in New England be Housed or Not?" by Mr. F. H. Shelton, Philadelphia, Pa.

"Acetylene," by Mr. W. R. Addicks, Boston, Mass.

"Temperature Corrections," by Mr. N. W. Gifford, New Bedford, Mass.

Several topics for discussion and questions for the Question Box will also be presented for the consideration of the Association.

Applications for membership, and all other matters requiring the consideration of the Directors, should be sent to the Secretary before Wednesday, Feb. 19. C. F. PRICHARD, Sec'y.

BRIEFLY TOLD.

PERSONAL.—Some time ago we received a most welcome and newsy letter from Mr. T. E. Connelly, one of the founders of the Connelly Iron Sponge and Governor Company, and as he was always well liked by the gas making fraternity, we will venture, even though the letter was a personal one, to convey to his many friends, in this public way, some hint as to his whereabouts. In the first place, the development of a weakness in his lungs prompted him some time ago to seek a climate less harassing than that of the Eastern seaboard, and he finally located himself and family in Colorado Springs, Col., we are joyed in saying they and he are prospering. Of course, there was no opening in the "Springs" for him in the gas business of that thrifty city, since the field in such respect was pretty well covered there long before he made it his home, but with that happy facility of adapting himself to circumstances which ever marked his career, he hung out his shingle as a financier, and now deals in all the varying brands of "Cripple Creek" mining shares, in which business may he ever have unvarying success. It is upon his physical condition, however, that we wish to particularly report, and it gives us unmixed pleasure to say that he is himself once more. Another gas man, the clever son of his respected father, who shares the voluntary exile of Mr. Connelly, is Mr. James Gardner, Jr., whose lungs were also impaired some months ago through a severe attack of pneumonia. The mountain air of the "Springs," in his case too, happily has mended the ravages of the disease that all but conquered him, and soon we may hope to have him back again in smoky Pittsburgh, buoyant and active as of yore. Mr. Connelly, in writing about his "silent" partner, says: "I wish you could see Gardner. His improvement is the most remarkable I have seen here." Still another of our invalids is Mr. Fred. W. Floyd, of this city, who is now rapidly convalescing from an attack of peritonitis, the complications and acuteness of which were alarmingly dangerous. And right glad are we to write it down that he is now to all intents and purposes his own bright, happy and reliant self.

NOTES.—The Hartford City (Conn.) Gas Light Company's annual meeting this year was, of course, a harmonious assemblage, for the shareholders' ears were greeted by rythmic numbers from the score of the annual reports submitted by the executive management. A wonderful expansion of business, transacted at a compensation fair to the gas consumers and just to the proprietors, was revealed by the documents submitted by General Manager Harbison, and coupled therewith was a detail of the betterments completed and to come on the manufacturing and distributing plants. The shareholders naturally continued the old Board of Directors, and the latter in turn reappointed the former executive administration. In prior issues of the JOURNAL we have reported some of the improvements completed during 1895 on the Hartford plant, and when those projected for this year are finished (it is presumed that everything will be in working order by October 1st), Mr. Harbison and his associates will have put their house in order for years to come. The scheme of betterment for this year includes the construction of a holder equal to the storage of one-half million cubic feet, the vessel to be erected on the new land recently acquired by the Company; the inlet and outlet pipes to the holder are to be 20 inches in diameter, and the outlet will connect with a 20-inch trunk distributing line to lead to the center of the city, there to feed into auxiliary main lines of 16 and 12 inches respectively. Provision is also made for an additional water gas set, of the U. G. I. type, the cupolas to be 7½ feet in diameter; for a complete new equipment of condensers, scrubbers and purifiers—this equipment to be up to the passing of one million cubic feet per day; and two new station meters, of one million each, complete the schedule. Of course, this work includes the erection of new buildings for the purifying sytem, meter station and valve house. The cost of all this will be not less than $150,000, and when the contracts are fulfilled the Hartford Company will have as complete a gas plant as it is possible to secure.——The Universal Gas Company, of Chicago, has issued a call for the payment of another 5 per cent. installment on its capital. Payment must be made on or before the 19th inst.——Mr. W. H. Hayden, of Bath, Me., has been awarded a contract for the reconstruction of the gas works at Hastings, Neb.——At the annual meeting of the Washington (D. C.) Gas Light Company the following Directors were elected: John R. McLean, Wm. B. Webb, Jas. W. Orme, John C. Bullitt and Geo. T. Dunlop.

A Contribution to the Literature on Purification of Gas.

[Prepared for the JOURNAL, by Mr. FREDERIC EGNER.]

In the article on "Carbureted Water Gas without Oil," published in the JOURNAL for December 9, 1895, p. 930, the writer referred to a certain system of purification, and, from the number of inquiries received, it is believed that "more light" upon the latter subject would be welcome to many of your readers, hence the present paper. Relating just how *we* do it, in order that others "skilled in the art" may go and do likewise—if they wish—one cannot well avoid making some statements of an elementary nature, which the author trusts those of your readers who are more proficient will excuse, remembering that he distinctly disclaims originality for the operations to be described, excepting only the present instance as of his own experience.

Our purifying material having become exhausted necessitated procuring something to replace it. Having a lime kiln, and oyster shells costing only about 2½ cents per bushel, we could have made good shell lime; and indeed, if the indirect, though real, lesser cost of the gas, in connection with better quality, were to be taken into consideration, *that* would have been the cheapest thing to do in the end. Unfortunately, however, these things are frequently undervalued, because not comprehended by those having to pay the piper, and when we read how (apparently) cheaply gas is made by the method and material used somewhere else, we are likely to be *driven* into doing the same thing, even *when we know better*, misled by a present saving of dimes, which may be easily seen and accounted for at the surface, regardless, however, of the dollars, which, with equal certainty, might have been ours had that system most suitable to our particular location been the thing done, instead of what someone else differently placed did with great success. Trusting that the reader will pardon the preceding brief generalization, we will return to our subject. We had made and used the well-known purifying agent produced by dissolving copperas in boiling water, saturating shavings with the solution, and afterwards treating the shavings with a little lime; also, many years before, a mixture (by weight) of about 40 per cent. clean iron borings, 50 per cent. shavings, or, better still, coarse sawdust, and 10 per cent. of slacked lime, wetting the whole with ammoniacal liquor from the scrubber, for the first time, until the iron rusted; and had employed the various mixtures or minerals offered for sale ready for use. But at this time we were offered a comparatively unknown material, whose chief recommendation to the writer was the guarantee *that said material contained at least 70 per cent. of iron, and was offered at a price for which a like quantity of plain iron borings could not be bought by us*, not to mention some of the tried efficacious purifiers on the market. Having procured a sufficient supply of that material, we found it to be of a dark brown color, and somewhat resembling coarse emery. It did not seem possible that it could be used upon the ordinary trays; or, when used, that gas would readily pass through it. In the latter respect we were agreeably disappointed, and in the former it was found that, after thoroughly wetting it, which was a difficult job for the first time, it would then lay upon the trays without sifting through. It acted like any other iron oxide gas purifying material, but as it is not the object of this paper to exploit this or any other purifying agent, we will pass on to the next step in our operations, and relate how we began revivification *in situ* upon this occasion, for it was not the writer's first experience with that method of purifying gas, while at the same time partly revivifying the material in use, having practiced same elsewhere for a considerable time with encouraging results. At the beginning we spread our new material 14 inches deep on a single layer of "Cabot's reversible purifier screens," removing same when foul, and revivifying in the well-known manner. We used a layer of slaked shell lime, 5 inches deep, on a second tier of screens over the oxide. In the meantime, we connected the outlet end of a small meter to the inlet of exhauster by means of a 1-inch pipe and stopcock—the inlet side of this meter was open to the atmosphere. Now, to avoid repetition, reader will please refer to the article mentioned at the outset in this paper, in which will be found a description of our apparatus, which will aid him to a better understanding of what is to follow.

At first we were making only water gas, but later on made both coal and water gas, mixing at exhauster inlet. By partly closing the valve between the relief holder and exhauster, we could regulate the flow of gas so as to have a pressure or slight vacuum between those points, which would, of course, be shown by the gauge set at inlet to exhauster.

Then, cramping the valve and observing the number of cubic feet passing the station meter under a certain vacuum, as shown by the gauge, and comparing with the number of cubic feet of air passing to

the exhauster through the small meter during the same time, we adjusted and marked the stopcock to admit from ¾ to 2 per cent. of air. While doing this, we also noted the candle power of the gas as shown by a convenient jet photometer. After the adjustment was made the small meter was removed, and the subsequent operations conducted merely by means of the marked stopcock in connection with the recorded vacuum corresponding to any per cent. of air which might be desired within the limits given, and frequent observations of the jet photometer. This work was somewhat tedious for the writer; but we are not so fortunate as some of our professional brethren, who, through the wealth or liberality of the companies they serve, are enabled to get many things denied to others, as, for instance, that of an attachment to the station meter, by means of which the quantity of air admitted can be readily and accurately fixed. However, our method costs very much less, is open to everybody, and, the adjustment once made, will do for a long time. Watching the jet photometer, we found, as near as the homely means employed would admit, that, with an admixture of air up to about 1½ per cent., the illuminating power seemed to improve; but going beyond that, it rapidly decreased, so we stuck to the former figure. The result was, that between the 19th day of March and the 19th day of October, 1895, we passed gas through the purifiers without once raising a cover. Neither did we have any trouble with abnormal pressure resisting the free flow of gas through the boxes during all this time; and the rate of flow was often as high as 20,000 cubic feet per hour, with purifiers 14 feet square, and 12-inch connections. Our hydraulic seal to purifiers is only scant 16 inches. At last the pressure at the inlet to purifiers increased, and we were obliged to make a change or risk a "blow-out." During the whole of the period mentioned the moistened test paper presented at the test cock of the middle box of the set was not soiled. On opening the foul box we found that the layer of lime had caused the trouble; but the oxide was also caked, and was removed in chunks. These, on exposure to the atmosphere, slowly revived, falling to pieces as they did so, and are now again ready for use, apparently as good as ever. The material used during that time was not all of the new kind, however. One of the boxes was charged with the copperas preparation, which presents, so to speak, only the thinnest kind of iron veneering on the shavings, to be acted upon by the gas.

At this date two of the three boxes in action contain the copperas material, and one the new oxide, and we have purified to date of writing (January 30) 66,800 cubic feet of gas per bushel of material, figuring in the customary manner, since making our last change. The middle box still shows clean, hence we cannot now tell how much longer we may be able to run before a change may become necessary.

During the seven months previously mentioned we purified 220,000 cubic feet of gas per bushel of material, with a portion of the same now again apparently as good as ever. Between the 19th of October and our last change, we had to raise the purifier covers several times to remove the lime, which caused trouble by caking hard, some of it having been in the boxes nine months, and had, of course, long ceased to be of any use. We have now discontinued the use of lime, but may resume it bye and bye.

The writer is aware of the fact that others have done as well, and possibly far better, in the same line of work, and these lines were only penned for the benefit of those who as yet have not reached like results, and some of whom have written to know how we did it. Please do not forget that the size of purifiers, as well as the consequent rate of flow through them, has a great deal to do with results in purification; and for those who lack experience or confidence in themselves *Wisdom* has her shingle out under various aliases on the back pages of this JOURNAL, as the reader can quickly see for himself. But hoping the matter has been made sufficiently plain, so as to be easily understood, we will now close.

Limits of Possibilities of the Cas Engine.

[By MR. GEORGE RICHMOND, in *Engineering Magazine.*]

The success of the gas engine, of which at least 50,000 must be in use at the present day, has not been due to its superior efficiency as a means of transforming heat into work. Availability, and convenience in use, as compared with steam, have been the chief factors in determining its adoption. The recent construction of gas engines of large power—300, 400, or even 600-horse power—and the reports of performances which the steam engine cannot hope to equal, and the possibility of still greater efficiency, have combined to force attention to the claims of the gas engine as a rival of the steam engine in its own domain. A fairly constructed gas engine of moderate, or even small, dimensions will convert into work 18 to 20 per cent. of the heat supplied to it. This is not only very much better than the performance of any steam engine of comparable size, but superior to that of the more elaborate triple expansion engine.

The following table gives some of the best results on record for the steam engine.[1]

Type of Engine.	Absolute Boiler Pressure Lbs. per Sq. In.	Steam Used per Hour per I.H.P. Lbs.	Percentage of W. Realized.	Thermo-Dynamic Efficiency.
Single-cyl. beam pumping engine (Mair-Rumbley)	59	21.3	46	0.11
Single-cyl. Corliss engine (Hill)	111	19.4	44	0.12
Single-cyl. Sulzer engine (Linde)	105	19.0	45	0.12
Two-cyl. compound beam pumping engine (Mair-Rumbley)	76	14.8	63	0.15
Two-cyl. compound Worthington "High Duty" pumping engine (Unwin)	75	17.7	53	0.13
	90	17.4	51	0.13
Two-cyl. compound pumping engine (Leavitt). Mean of two trials	114	14.05	60	0.16
Two-cyl. compound high speed single acting engine (Willans)	180 (about)	14.26	54	0.16
Triple marine engine of S. S. "Iona" (Kennedy)	180	13.35	58	0.17
Triple experimental engine (Reynolds)	207	12.68	59	0.18
Triple high speed single acting engine (Willans)	190 (about)	12.74	60	0.18
Triple Sulzer engine (Schroter)	171	12.2	64	0.19

The most sanguine engineer hardly expects to obtain any serious improvement on the best results now recorded for the steam engine. A little less than 11 pounds of steam and a little more than 1 pound of coal to the horse power is apparently the ultimate limit of steam engine economy. On the other hand, gas engines using "producer" gas regularly yield 1-horse power to about ¼ths of a pound of coal. In both cases the figures are in terms of indicated horse power, but the mechanical efficiency of the gas engine is about the same as that of the compound or triple-expansion engine.

There are probably few industries in which the cost of power bears so large a ratio to the total expense that ¼th of a pound of coal per horse power would in itself have much weight in determining the choice. Nevertheless, the gas engine, having established its claim to consideration, could, and undoubtedly will, be adopted in many cases with great advantage, in preference to steam power. For it must be remembered that the present claim of the gas engine is not simply that it is well adapted to special applications; all this has been conceded—with a certain patronizing condescension, it is true. The advocate of the gas engine no longer pleads extenuating circumstances, but boldly claims recognition on an equal footing with steam. This confidence is based partly on accomplished facts, but largely on expectations of greatly increased efficiency. As to the maximum efficiency to be obtained in practice the doctors differ; a conservative writer puts it at 40 per cent.; a more hopeful one proposes a plan by which upward of 70 per cent. of the heat supplied is expected to be turned into work. This would mean less than half a pound of coal in the one case, and about a quarter of a pound in the other, for 1-horse power per hour; should either of these efficiencies be realized, the fate of the steam engine would be sealed.

The operation of a gas engine of the ordinary 4-stroke type is too well understood to need description, but it may be pointed out that its action and theory do not differ essentially from those of the steam engine. We may consider that air, instead of water, is pumped into the boiler, and that each cylinder charge is heated on its way (after being shut off from the boiler) to the temperature it acquires by combustion in the cylinder. We perceive at once an obvious advantage in performing the combustion actually within the cylinder, since the loss of heat in the chimney is eliminated.

It is usual to refer all heat engines to the perfect heat engine imagined by Carnot, in which the efficiency depends only on the initial and final temperatures being very simply expressed by the fraction:

$$\frac{\text{Temperature of Supply—Temperature of Rejection}}{\text{Temperature of Supply.}}$$

This in many cases is extremely misleading, and justifies suppositions very far from the truth. As a matter of fact, it is very easy to determine, for any given heat engine employing in a given cycle an agent whose physical properties are known, the precise amount of heat that can possibly be converted into work under the given conditions. The ratio of this to the total heat supplied is the highest efficiency obtainable, and the only one with which we have any practical concern, except when the relative advantage of different agents is in question.

This question, which is usually ignored in the loose application of the

1. "The Steam Engine and other Heat Engines," Ewing.

Carnot ratio $\frac{T^1 - T^2}{T^1}$ to the ordinary gas engine, is precisely the most important in the present connection. A gas engine working on the "Otto" cycle could not possibly utilize as much heat (barely half as much) as a steam engine working between the same temperatures, and the current statements that the gas engine utilizes a much smaller proportion of the available heat than the steam engine are greatly exaggerated. Failure to recognize this fact not only raises expectations which can never be realized, but diverts the mind from the fact that an approach to the ideal efficiency can be realized only by a radical departure from the "Otto" cycle; if this is not practicable, then we must be content with a moderate improvement in the efficiency of the gas engine. For example, the statement that the gas engine is capable of converting into work 70 or 80 per cent. of the heat supplied to it is not true as applied to the gas engine, as we are acquainted with it. The "Otto" cycle is now so universally adopted that no other is ever suggested by the term gas engine. Now, as this engine is usually run, the heat available for transformation into work does not amount to more than 34 or 36 per cent. of the heat supplied. Therefore *an ordinary gas engine will compare favorably with the best compound or triple-expansion engine in both thermal and mechanical efficiency.*

In the above table the third column gives the percentage of available heat actually converted into work. The available heat in this case is not that of an ideal cycle between highest and lowest temperatures, but that of the actual steam engine cycle. Now, a gas engine converting 20 out of 34 per cent. of available heat realizes about 60 per cent., which is higher than the average realization of the steam engines in the table. The corollary to this is that the present gas engine is susceptible of only very slight improvement in efficiency. Theoretically the efficiency could be increased almost indefinitely by increasing the compression, and one plan contemplates at least 90 atmospheres. On this point an expert, entitled to the most respectful attention, writes as follows:[1]

"Can this principle be much further extended in its application? In the author's opinion, no. By undue increase of compression the negative work of the engine would be much increased, and the strains would become so great that heavier and more bulky engines would be required for any given power. Friction due to this increases more rapidly than efficiency; consequently the gain in indicated efficiency would be more than compensated by loss of effective power.

"One means of improving the cycle itself has received a great deal of attention from inventors; in fact, nearly every maker of gas engines has tried to utilize it. The circumstance that in the gas engine the burnt gases are allowed to escape at a pressure much above that of the atmosphere never fails to impress the casual observer. To him compression seems an evil—necessary perhaps—but complete expansion appeals so strongly to his imagination that he is astonished that no one, prior to himself, has thought of such an obvious opportunity of improving the efficiency. Many ingenious schemes for realizing this modification of the "Otto" cycle have failed; their failure hitherto has been chiefly due to the fact that it involves a great increase in the volume of the cylinder for a given power. A consideration of the fact that, for a given volume of piston displacement, the *amount* of heat involved is very different in the two cases will indicate the reason why methods suitable for the steam engine are entirely inapplicable to the gas engine.

At a pressure of 45 lbs. one cubic foot of steam contains 130 thermal units, while a cubic foot of air at 45 lbs. pressure and 740 deg. (the absolute temperature of the exhaust usual in practice) contains only 13 thermal units. From this it is obvious that the losses incidental to compounding, which would be insignificant in the case of steam, would be absolutely fatal in the case of the gas engine. The most promising attempt to utilize more complete expansion was that of the Atkinson engine; but notwithstanding the fact that compounding took place within one single cylinder and with great rapidity, the gain was insignificant, and, taking into account the increase of available energy, the thermal efficiency of the engine was reduced.

If we are thus cut off from improvement whether by increasing the compression or by increasing the expansion, the conclusion is inevitable that the gas engine is as near to its final efficiency as the steam engine. There would seem, however, to be more chance of success in the line of increased compression, the difficulties in this case being chiefly mechanical, and not, as in the other case, physical. An extreme application of this principle was planned by Herr Diesel.[2]

1. "The Gas Engine," Dugald Clerk. J. Wiley & Sons.
2. "Theory and Construction of a Rational Heat Motor," R. Diesel. Translated by Bryan Donkin Spon.

The extreme diversity of views and emphatic statement of them current might be moderated by a clearer apprehension of the principles involved; it is equally pertinent to remark that the flippant charge of incompetency made against gas engineers is entirely unwarranted. A steam engineer can design a steam engine on any given lines, and predict very closely the result; a corresponding prediction for a gas engine departing from known and tried conditions is a sign, not of knowledge of the subject, but of ignorance of its complexity. The final result to be achieved may be perfectly definite, but experience shows that it can be approached only by tentative balancing of conflicting conditions. The theory of the gas engine, as of any other heat engine, is really very simple, and, in view of the necessity of keeping them in mind in this connection, an attempt has been made in the appendix to this paper to present the leading facts as free from technicalities as possible. It may be perfectly true, as asserted, that the art is very much further advanced in Europe than in America. Nevertheless, the importance of the gas engine of large power, as a possible rival to the steam engine, is receiving recognition. It is said that the Westinghouse Company is preparing a gas engine which is to be an advance upon those at present in use. The information has come to the public in the interview form, with characteristic vagueness as to detail; confidence, however, is inspired by the fact that the performance (three-quarters of a pound of coal to the horse power) claimed is well within possible limits. The De La Vergne Refrigerating Machine Company, which has created a special department for the manufacture of oil engines, has for several years been collecting data and studying the subject of gas engines of large power, and is understood to be prepared to put them on the market, should their investigation lead to any substantial improvement on existing types. Others are doubtless working at the same problem, and it is satisfactory to know that the interests of the gas engine are in the hands of firms capable of intelligent and, above all, sustained effort; nor is their any reason to fear that America will be left behind in this industry.

Oil engines (which constitute another special form of the hot-air engine) are apparently destined to supplant both gas engines and steam for moderate power. They have all the advantages of the gas engine, with the additional advantages of costing considerably less to run and being available in situations where gas cannot be obtained. The gasoline engine has enjoyed an ephemeral popularity, and will probably still continue in use where neither gas nor oil has been made available. This is notably the case in the so-called "horseless carriage" or automobile—the application at present most in evidence.

The difficulties in this case are complex, and about equally divided between the motor and the transmission mechanism. The partial mechanical success obtained in Europe has created a craze for this class of vehicle. At present the inventors are exhausting all the possible ways of "how not to do it." Nevertheless, to the careful observer some of the most pronounced failures are more suggestive than the most correct designs. The name "horseless carriage," while it correctly represents the sphere of present activity, also indicates wherein the same is at fault. No really successful self-propelling vehicle will be produced until not only the horse but the carriage builder is eliminated. The Pullman car is not a horseless stage coach, and the motor vehicle of the future will not be a horseless carriage.

As regards the motor, no new principle is likely to be evolved, while we may expect many novelties in the way of mechanical construction. When the machine proper is lightened to the greatest possible extent, there still remains the necessity of carrying water for the cylinder. One horse power means the turning of heat into work at the rate of about 43 thermal units per minute. The heat passing into the jacket is about 2½ times this, or, say, 100 thermal units per minute. If a 3 or 4-horse power motor is used, there is more heat than can be gotten rid of by conduction in any air-cooling device of reasonable dimensions, and a considerable waste of water must be carried, boiled away, and renewed.

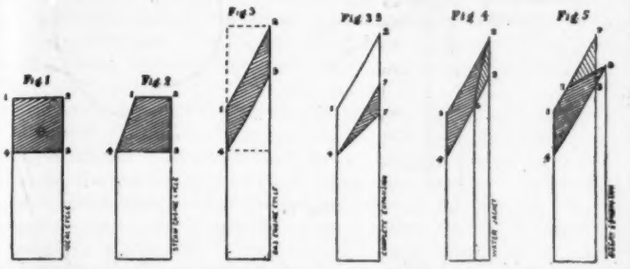
One inventor boldly "denies the allegation and defies the alligator," and also explains. The first explanation was that the motor, by virtue of using liquid gasoline, was a refrigerating machine in combination with an engine. As the latent heat of gasoline is about 1 per cent. of the heat of combustion, this explanation is clearly inadequate. The second explanation is a double spark, the first cooling and "ripening" the mixture, while the second ignites it.

The interest in this explanation is confined to the treatment of it in the technical press, as indicating the extent to which the principles of thermodynamics are or are not accepted, as the case may be. If one is willing to sacrifice the efficiency, it is easy to see how, in accordance with well-known principles, a large portion of the jacket heat may be

thrown into the exhaust. The mean temperature of the cylinder must be maintained within moderate limits. Now, the initial temperature may be reduced by working with a very weak mixture, which results in delayed combustion, and the final temperature may be reduced by increasing expansion, the simplest and crudest method of obtaining which is to choke the suction. For further reduction of the mean cylinder temperature add misfires in sufficient quantity.

Appendix.

If the quantity of heat supplied to an engine be represented by a rectangle whose height is equal to the absolute temperature (on any convenient scale) at which the heat is supplied, then this may be divided into two parts by a horizontal line drawn at the temperature at



1. Ideal Carnot Cycle. 2. Steam Engine Cycle. 3. Otto Gas Engine Cycle. 3a. Ditto with Complete Expansion. 4. Ditto with Water Jacket. 5. Effect of Delayed Combustion (Nachbrennen.)

which the heat is rejected (Fig. 1). The ratio of the part cut off from the line to the whole line is evidently $\frac{T^1 - T^2}{T^1}$, and the rectangles on these lines represent respectively the heat transformed into work and the total heat. Moreover, following the shaded rectangle around is equivalent to reading off the physical changes of the agent. Taking steam, for example, and commencing at the corner marked 1. From 1 to 2, heat is added without increase of temperature (water evaporated at temperature T^1). From 2 to 3, the temperature is reduced without addition or removal of heat (adiabatic expansion). From 3 to 4, heat is removed without change of temperature (condensation). From 4 to 1, temperature is realized without addition or removal of heat (adiabatic compression). This is the ideal cycle, and that of the ordinary steam engine differs from it mainly in the fact that hot water at temperature T^1 is not produced by compression of partially condensed steam, but by application of heat at constant pressure in the boiler. The rise in temperature, then, from 4 to 1 is accompanied by a progressive addition of heat, and the line bends to the right, as in Fig. 2. The ratio of the shaded portion to the whole area is less than in the previous case, and this new ratio is the highest efficiency obtainable with the ordinary steam engine. A consideration of these figures will explode a popular fallacy, which dies hard—namely, that latent heat is a great drawback to the use of steam as an agent. It is obvious that, the greater the latent heat of the agent, the nearer the practical cycle of Fig. 2 approaches the ideal cycle of Fig. 1.

In the case of the gas engine on the "Otto" cycle the highest temperature is reached partly by compression and partly by the addition of heat by combustion at constant volume. In Fig. 3 compression raises the temperature from 4 to 1; and 1 to 2 marks the rise in temperature in consequence of the addition of heat, the amount of which is represented by the area swept out by the vertical line in travelling from 1 to 2. Since the specific heat of air at constant volume is only .169, this line, 1–2, is very much steeper than in the case of heating of water. From 2 to 3, the temperature of the air is reduced without addition or removal of heat (adiabatic expansion). The expansion is continued until the initial volume is reached, or the point 3 lies upon a line of equal volume drawn through 4. The shaded area, as in the previous case, represents the total amount of heat which it is possible to convert into work in the "Otto" cycle. If we draw a horizontal line through the points 2 to 4, we obtain the rectangle representing the available heat for an ideal engine working between the same temperature 2 and 4. The difference between these areas indicates very clearly the absurdity of applying the Carnot ratio to the "Otto" gas engine. All the facts and possibilities of this cycle can be read at a glance from this figure. It is obvious that the efficiency is proportional, not to difference between the highest and lowest temperatures, 2 and 4, but to the difference between the temperatures produced by compression and the initial temperature 4. From this it follows that the efficiency of the theoretical "Otto" cycle can be increased to any desired degree by increasing the compression. It does not, of course, follow that this would be true in actual practice.

The gain by complete expansion is seen in Fig. 3. The expansion, instead of stopping at the point 3, is continued till the atmospheric pressure is reached (Fig. 3*a*). At the point 4 the gas is at atmospheric pressure, and a line of equal pressure drawn through this point will be less steep than the line 4–3, since the specific heat of air at constant pressure is greater than at constant volume. This line will cut the vertical, 2–3, at the point 5, and the additional work obtained by complete expansion is that represented by the triangle 4–3–5. Not only is the available heat of the gas engine much less than that of the ideal engine of similar range, but it is further diminished by two circumstances—the one physical and easily understood, the other chemical and somewhat obscure. The temperature obtaining in the gas engine would make the cylinder nearly or quite red-hot, and render proper lubrication impossible. Hence the necessity of the water jacket, which carries away nearly one-half of the total heat supplied to the engine. This involves a great sacrifice of the available energy, but if the water jacket were suppressed the greater part of the heat it eliminates would go into the exhaust.

The action of the water jacket may be seen in Fig. 4. During expansion heat is removed to an amount represented by the area swept out by the vertical in traveling to the left from 2 to 6. The area of available energy is diminished by the triangle 2-3-6, and the exhaust heat is diminished by the area swept out by traveling from 3 to 6. This latter quantity of heat belongs to the exhaust or rejected heat, and it is immaterial whether it passes out in the jacket or the exhaust.

The sum of these two does not represent the 50 per cent. of jacket heat for a large part of this is taken up during the exhaust stroke. The point 6 can be determined when the final temperature or pressure of expansion is known, and the two areas in question would be ascertained with sufficient accuracy by drawing a straight line from 2 to 6. On the indicator diagram this represents an expansion line considerably below the adiabatic curve. But the second circumstance has an opposite effect, and the combination of the two generally results in throwing the actual expansion line above the adiabatic. The reference here is to retarded combustion, or the celebrated "Nach-Brennung." It is found that at the moment of ignition the theoretical temperature 2 of Fig. 3 is not obtained, and consequently only the heat due to partial combustion is applied along the line 4–2, the remainder being added during the expansion. Fig. 5 represents this phenomenon; the first ignition supplies heat from 1 to 7, and the expansion line is carried out of the vertical, over to 8, by the subsequent addition of heat. If the area by the path 1–7–8 (Fig. 5) is the same as that from 1 to 2 (Fig. 3), the combustion is completed at the end of the stroke. If it is less, then unconsumed gas is passed out with the exhaust. The positions of both the points 7 and 8 depend on a variety of circumstances, the most important being the proportion of gas to air at the time of ignition. Each of the circumstances indicated by Figs. 4 and 5, taken alone, represents a thermodynamic loss, but their combination and superposition would not therefore necessarily result in a practical loss—might even result in gain.

The "Sterling" hot air engine follows very closely the "Carnot" cycle, and there is no great difficulty in making the ordinary gas engine follow the same cycle. We have seen that the quality of steam which causes its practical cycle to approximate closely to the ideal cycle is its large latent heat. But latent heat, so called, is nothing more than heat transformed into work, largely molecular in the case of steam. In the gas engine, if the work is done at the rate of generation of the equivalent heat by combustion, we have an exactly corresponding condition. Moreover, we have become acquainted with concurrent combustion and transformation into work in the phenomenon of "Nach-Brennung." The line 7–8 in Fig. 5 may become horizontal, and may easily be conceived to start at 1. It is merely a question of controlling the combustion and dilution.

Returning to our original Fig. 1 of the ideal cycle, suppose air (largely in excess of that required for complete combustion) and gas to be separately compressed to the temperature 1, assumed to be at least high enough for spontaneous combustion. If the air alone were let into the cylinder, it would be cooled by doing work against the piston. If sufficient gas to combine with the air were introduced, the temperature would instantly rise. But, if the gas is introduced in such quantities that the heat of combustion just balances the cooling of the expanding mixture, a constant temperature will be maintained, the heat supplied being equivalent to the work done. At 2 the supply of gas and air is

cut off, and the temperature is reduced to 3 by adiabatic expansion. If at this stage it is compressed at constant temperature to 4, we have the complete Carnot cycle. This is substantially the cycle proposed by Herr Diesel.

On the Photometry of Differently Colored Lights and the "Flicker" Photometer.

By Mr. Frank P. Whitman.

In November, 1893, during measurements on some colored discs, it became necessary to know the relative luminosities of the colored papers employed. An attempt was first made to estimate the luminosity directly by comparison with Maxwell discs of black and white, smaller in diameter, and mounted on the same axis. The relative proportions of black and white were changed until, on rotation, they formed a gray, which was estimated to be about equal in brightness to the colored disc under examination. This method, practiced by certain experienced observers, doubtless has afforded good results, but in my hands proved difficult and uncertain.

Trials were then made by four other observers, all somewhat skilled in physical measurement, whose general color sense was found to be similar, but their estimates of luminosity were found to vary in such an irregular fashion as to make any comparison impossible.

Later experiments, carried out with the help of some 30 undergraduate students, led to similar results. Differences of 50 per cent. between two different observers frequently arose, when the light to be compared differed no more than an ordinary from a Welsbach gas burner; while the same observers, working with a light of the same color, would agree at least within 2 or 3 per cent.

By practice the margins of difference may be rendered smaller, yet experts often differ in their estimates of the brightness of arc lights when compared with standards of different color; and it is questionable whether one can always be sure that by practice in such measurements he gains greatly in accuracy. His measurements agree with each other better than at first, but if his method of comparison have in it something of an arbitrary or personal quality, as it must from the very nature of the case, it remains uncertain whether he may not be fixing himself in an erroneous practice rather than approaching a correct one.

The character of these results, and the need of some more exact method of comparing color luminosities, led to the consideration of Prof. Rood's "flicker" experiments.

Rood prepared about 50 gray discs differing successively, as equally as possible, in depth of tint from black to white. If a dark shade was combined with a light shade in the usual way, and rotated rather slowly, the familiar unpleasant sensation known as a flicker was produced; but if successive pairs, more and more nearly alike, were chosen, the flicker became less, until it almost or quite disappeared. Nearly the same effect was produced if, instead of a gray, some other color was substituted on one of the discs. It was always possible to combine with it a gray disc of such a shade that the flicker nearly ceased, showing that this sensation is apparently independent of the wave lengths of the lights compared, and dependent only on their relative luminosities. Prof. Rood suggests that the principle may be easily applied to ordinary photometric work, but indicates no method. The special arrangement described in his paper serves admirably to compare pigments, when in such form that they can be spread upon discs and mounted in the whirling machine.

For ordinary photometric purposes, however, there is necessary some arrangement by which luminosity can be varied continuously instead of step by step, as with a set of gray discs, which can be mounted on a photometer bar so as to compare colored lights as well as colored pigments, and which is reasonably quick and convenient in use. No doubt there are many ways of applying Prof. Rood's flicker principle; the one which I, after some trial, found most successful was as follows:

A card was cut in the shape *A H B G*, in the figure, so as to form two semicircles of about 5 and 8 cm. radius respectively, joined along a common diameter. This could be rotated at any desired speed about the axis *K*, in earlier experiments by clockwork, but afterward, and more conveniently, by hand. A diagrammatic plan of the apparatus as used is shown in the figure. *D E* represents the photometer bar, *A B* is the revolving disc, *C* is a card, which may be white or colored with any pigment which it is desired to study, *F* is a tube through which the observer looks. It is evident that when the apparatus is in the position shown in the figure, the outer portion of the revolving disc only will be visible through the tube, but when the disc is rotated half a turn, the small semicircle will not come into view at all, and the observer will only see the card *C*. As the disc revolves, the two pieces will be presented to the eye in rapid succession, and, if they differ in luminosity, will produce the sensation of "flicker." If equal lights are placed at the ends of the photometer bar, the relative illumination of the card and disc can be varied by sliding the photometer along the bar. The flickering sensation can thus be entirely destroyed, whatever the colors are upon the card and disc. (Various colors were tried upon the

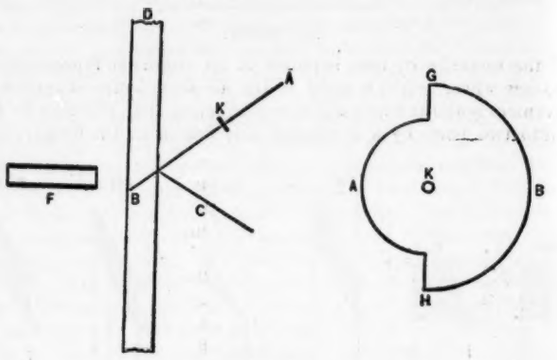


Fig. 1.

disc—red, white, and different grays—but white was finally adopted as in all cases the most convenient.) When the proper position of the photometer was reached, not only did the flicker vanish, but the sense of color in the field of vision became much weaker or entirely disappeared so that it was frequently difficult or impossible to tell what color was upon the card. A slight movement of the photometer in either direction revived the sense of color and re-established the flicker. The results obtained with this instrument were surprisingly good in ease, rapidity and precision.

Work was interrupted at this point until May, 1895, when the measurements were taken up again, and the instrument itself somewhat carefully studied.

The colors used for experiments on pigments were chosen from the well known series of colored papers made by the Milton Bradley Company, of Springfield, Mass., and included the whole range of the spectrum. These papers were pasted upon perfectly flat cards, and placed successively in the position marked *C* in the figure. Three curves are

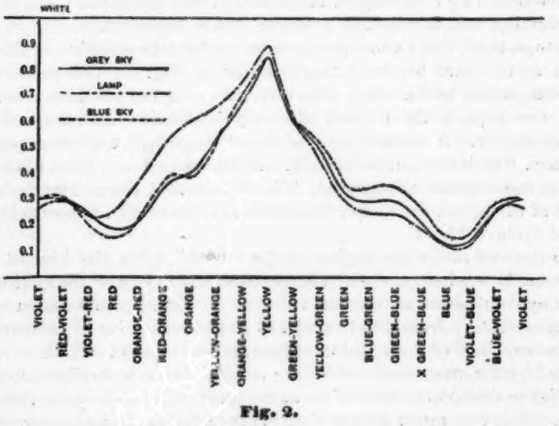


Fig. 2.

shown to illustrate the capacity of the instrument, exhibiting the relative luminosities of these 19 colors, when illuminated by the light of a kerosene lamp, of a dull gray sky, and of a bright blue sky.

The predominance of the lamp curve toward the red end of the spectrum and of the clear sky at the other end is manifest, while the similarity of the curves shows that the measurements are of like character and definiteness, whatever the source of illumination. In all these cases the revolving disc was white, lighted by a lamp, while the colors on the card were exposed to the light under investigation. Since the flicker effect is independent of the wave length, any source of light which is constant may be used to illuminate the disc without changing the results dependent on the luminosity of the colored card. The curves from sky light and cloud light, though the mean of several trials, were not

entirely satisfactory on account of the comparatively inconstant brightness of these sources of light. These observations on lamp light, however, were made twice, at an interval of over two months, with practically identical results.

A greater interest, perhaps, lies in the instrument itself. An apparatus so new and depending on a physiological principle which has been so little studied, presents many points for investigation, before its utility as a practical photometric apparatus is assured. The remainder of this paper is occupied with a study of some of these points.

1. The precision of setting, as compared with other types of photometer, was tested in over 100 settings on 19 different colors. The difference between two successive readings was seldom more than 1 per cent., though a few readings differed as much as 2 or 3 per cent. As these readings were made over the whole range of the spectrum, it seems fair to say that the instrument can be used upon lights presenting the widest difference of wave length, with a precision approaching that of ordinary types of photometer when comparing lights of the same color.

2. Since the photometer depends, not on the actual comparison of like quantities, but on the distinctness of a peculiar physiological sensation—the flicker—it is worth while to see whether different observers will agree. To test this question, and incidentally to try the instrument with colored lights instead of colored papers, both disc and card were made white, and equal lamps, the colors of which could be changed at pleasure by the interposition of colored glass, were placed at the ends of the photometer bar. Two observers, whose eyes were known to be similar, compared successively the brightness of the two naked lamps, first by an ordinary photometric method, then by the flicker. A red glass was then placed in front of one lamp, a green glass in front of the other, and the same observations were made again. One of the two observers had never seen the instrument before. The results follow, each being the mean of four or five concordant observations. The actual readings are given in feet and hundredths, not reduced to comparative luminosities. One lamp stood at 3.00, the other at 9.00 on the photometer bar.

	Observer F.		Observer W.	
	Ordinary.	Flicker.	Ordinary.	Flicker.
Both lights naked.....	5.98	5.96	5.98	5.98
Left lamp red, right green....	5.59	6.79	6.08	6.88

Thus, in the last case, the setting of F. by direct estimation differed from that by flicker by 1.20 feet, that of W. by 0.80 foot.

The setting of F. by estimation differed from that of W. by 0.49 foot; while F.'s flicker setting differed from W.'s by only 0.09 foot. The last disagreement is comparable with the errors of observation.

At a later time, three other observers, making comparisons for technical purposes between coal oil lamps and a standard candle which differed from them somewhat in color, were able with the flicker photometer to obtain accordant results among themselves much more easily and surely than by ordinary methods.

3. Two "discs" like those in the cut were mounted on the same axis in the photometer. By sliding one upon the other, the fraction of a revolution during which the card was visible could be varied between 180° and 0°. The relative length of exposure of the eye to the two lights could thus be varied within wide limits. Several comparisons were made of lights differing widely in color, and with openings from 22½° to 180°, but no differences in reading were observed that could be traced to this cause. While it is true that the sensitiveness of the retina differs for lights of different wave lengths, and probable that differently colored lights require different periods of time to produce equal sensations in the eye, it appears from these experiments that there is time, at the comparatively slow rate of rotation of the disc, for every color to pro duce its full effect, so that errors which might be produced by irregularity in rate of rotation or in shape of the disc are negligible.

4. In much of the work the photometer and standard lamp were kept at fixed points, and the balance obtained by moving the other light, thus making all comparisons at the same actual degree of illumination. This method of using any photometer has some obvious advantages, though the sensitiveness is not quite so great as when the photometer itself is moved. To determine whether the absolute brightness has any effect on the settings, measurements were made of six colors—red, orange, yellow, green, blue, violet—under widely differing illuminations. When the light was faint the measurement became much more difficult, but the results obtained with bright and faint light did not appreciably differ, showing that the well-known greater sensitiveness of the eye to blue light is not important in measurements made under conditions proper to this photometer. When the illumination is small the flicker is very faint and may be invisible while the photometer is moved over as much as 6 or 8 cm., but by reading the points each side of this space where the flicker again becomes visible, and taking the mean of the two readings, results may be obtained almost as trustworthy as with brighter light. It should be remarked that this method in general depends for its value somewhat on the state of the eye. It appears certain that two normal eyes, in a reasonably fresh condition, would obtain like results, but if the eye is wearied from long-continued observation or loss of sleep, the perception of the flicker becomes more difficult, and the difficulty appears to vary with different colors in a way that has not yet been studied.

5. The question still remains, whether the flicker method gives in all cases a true measure of luminosity comparable to that which would be obtained by any more direct photometric method. To test this, the luminosity measures afforded by Maxwell's discs were used.

Suppose, for example, three colors—say red, green, blue—combined on the whirling machine into a neutral gray, which is matched by the combination of a black and a white disc. The amount of white in the latter combination, corrected for the white light reflected by the black portion, is of course the measure of the luminosity of the colored disc in terms of white, which quantity, again, is dependent upon the luminosities of the three colors of which it is composed.

If now the fraction of the whole circle occupied by any color is multiplied by its luminosity as measured with the flicker photometer, the result will be the amount of white equivalent to that colored sector, and the sum of the results obtained by treating each of the colored sectors in this way should equal the amount of white in the black and white disc. Two examples are given below. The circumference of the disc was divided into 100 equal parts, so that the numbers given are direct percentages of the whole circle.

The upper row of figures in each case is the ordinary color-disc equation. The second is the luminosity of the given colors referred to white, as measured by the flicker, the lower line gives the product in each case. The sum of these products given under white should be the same as the white in the upper row, which is the corrected reading from the black and white Maxwell discs.

	Red.	Green.	Blue.	White.	Red.	Green-Yollow.	Blue.	White.
Color-equation	40.5	49.2	10.3	22.6	18.5	34.0	47.5	30.4
Luminosity	0.238	0.295	0.106	—	0.238	0.617	0.106	—
	9.64	14.50	1.09	25.23	4.41	20.96	5.03	30.40

Fourteen such trials were made with different colors, the results differing by one to three per cent. from exact quality.

Summary.—The flicker photometer used to compare lights of any color approximates in convenience and accuracy any of the ordinary photometric appliances used with lights of the same color. Different observers whose vision is normal obtain like results.

Irregularities in the division of the disc or the rate of rotation are without appreciable effect on the precision of the measurements.

Differences in the absolute brightness of the lights compared present no greater difficulties than in any photometric method.

The instrument gives a true measure of luminosity comparable with that obtained in other trustworthy ways.

Willson's "Process of Producing Illuminating Gas."

On January 28th, U. S. Letters Patent (No. 553,550) were granted to Mr. Thomas I. Willson, of New York, for "a new and useful improvement in the production of illuminating gas," the title to which was subsequently assigned by him to the "Electro Gas Company of West Virginia." Using the words of the specification:

I have discovered that, under certain conditions, combustible gas can be enriched by adding thereto the products obtained by the heating of acetylene.

If acetylene is added to a non-luminous water gas in its ordinary condition, the illuminating power of the acetylene after a short time is practically lost. If, however, there be added to such gas the gaseous products obtained from heating acetylene, the illumination power remains.

The heat to be applied should be sufficient to cause a change in the acetylene gas into its higher polymers and other products, while at the same time carbon is deposited which is not added to the resulting gas being enriched. This can be done by a heat approximating a low read heat. I may add such decomposition products either by primarily heating the acetylene and adding the gaseous products in determined percentage to the gas, or I may add the acetylene and pass the combustible gas carrying the acetylene through a fixing retort or heated tubes. They should be, approximately, of a red to a bright-read heat, and I may add from ten to twenty-five per cent. of the volume of combustible

gas in such decomposed products of acetylene. The result of this action is to prevent a decomposition of the acetylene, which would occur if the acetylene were added to such water gas without either prior or subsequent heating. I am not informed as to what the chemical action is; but it is probable that a new carbon compound is formed under these conditions; and it is the formation of such compound and the consequent destruction or reduction of the illuminating power that I am desirous of avoiding. It is probable that a combination may occur between the hydrogen of the water gas and the acetylene, as follows:

$$CH{=}CH + H_2 = CH_2{=}CH_2$$
$$CH_2{=}CH_2 + H_2 = CH_2{-}CH_3.$$

I may add the products obtained by heating acetylene as well to coal gas or enriched water gas; but the especial advantages of the process are to be derived from the addition of such products to a practically non luminous gas.

I do not claim broadly the heating of acetylene in hot tubes for the production of benzol, the same being old.

What I claim as my invention, and desire to secure by Letters Patent, is:—

1. The process of producing illuminating gas by adding to a combustible gas the gaseous products of acetylene produced by heating the same in a heated chamber to a low read heat, substantially as described.

2. As a new product, illuminating gas consisting of the combination of a combustible gas and the gaseous products produced by heating acetylene, substantially as described.

The Effects of Atmospheric Conditions on the Hefner and Pentane Standard Lamps.

The London *Journal* says that Mr. John Methven some time ago drew attention to considerable variations in the light emitted by standard candles, compared with a constant source of light, according to the degree of humidity of the atmosphere. The light of the candle was increased by about 8 per cent. when it was burning in air freed from aqueous vapor. He also found that air saturated with moisture at different temperatures affected the lighting value of flames burning in it. A diminution of 10 per cent. in the light of the standard argand flame taking place with a rise in temperature of the saturated air from 50° to 75° Fahr. The Photometric Standards Committee of the Board of Trade, who concluded their labors last year, devoted a section of the appendix to their report to a review of Mr. Methven's work, and to a description of experiments made by them. The Committe experimen ted with the one-candle pentane unit, the ten-candle pentane argand and the normal "London" argand gas-flame. They came to the conclusion that "although by abnormally saturating or drying the air supplied to a flame, variations as great as those obtained by Mr. Methven undoubtedly occur, yet that in a well-ventilated testing room, with the temperature kept within a narrow range, no such great differences are to be found." In support of their conclusions, the Committee refer to a long series of experiments made by Mr. Vernon Harcourt, in which the one-candle pentane unit was tested against an electrical standard, in order to ascertain the effect of the height of the barometer upon the light emitted from the flame. No variations were observed which led Mr. Harcourt to suspect that humidity had any influence upon the amount of the light emitted. These results appear fairly conclusive; there has recently been published in the "Zeitschrift für Beleuchtigungswesen" a report by Dr. Emil Liebenthal, on behalf of the German State Physical and Technical Institute, on "The Effects of Atmospheric Conditions on the Hefner and Pentane Lamps." This report forms a natural corollary to the one issued in 1893, in which the value of the Hefner unit was found to be uniform, and was defined in terms of the English and German standard candles. The atmospheric conditions had been disregarded in the determinations on which the results of that report were based. In the investigations recorded in the present report, electric incandescent lamps of constant power were used as a standard of light, independent of atmospheric influences.

Experiments with the Hefner Lamp.

Effect of Atmospheric Moisture.—Variations in the value of the light of the Hefner lamp having been observed, it was suspected that variations in the amount of aqueous vapor in the atmosphere formed the chief disturbing influence. The formation artificially of an atmosphere containing precise quantities of aqueous vapor being fraught with difficulties, it was decided to make observations under the ordinary variations of atmospheric humidity during an extended period. Observations with the hair hygroscope showed that atmospheric moisture was actually the chief factor in the production of variations in the value of the light; and therefore accurate estimations of the aqueous vapor made by means of the Assman aspiration hygrometer at the same time that photometric readings were made. The results have been tabulated in volumes of aqueous vapor per 1,000 volumes of dry air, free from carbonic acid, at the prevailing temperature and pressure. Then if x is equal to the number of such volumes of aqueous vapor, and the illuminating power observed be plotted out as a function of x, a curve which is substantially a straight line is obtained, and the dependence of the illuminating power y upon x may be expressed by an equation of the first degree; thus—

$$y = a - bx$$

the values deduced from the whole of the observation of a and b being $a = 1\ 049$ and $b = 0.0055$. Hence the relation between y and x must be in the form—

$$y = 1.049 - 0.0055x \quad \text{(I.)}$$
$$\text{or} \quad y = 1.049\,(1 - 0.0055x) \quad \text{(II.)}$$

Therefore the illuminating power diminishes constantly as the proportion of aqueous vapor rises, to the extent of 0.0055 per volume of aqueous vapor per 100 volumes of dry air for each Hefner unit or about 0.55 per cent. The illuminating powers corresponding to all the observed values of x have been calculated according to equation I., and the differences between them and the observed illuminating powers stated in percentages of the illuminating power. Excluding one improbable result, the greatest difference between observed and calculated values is 0.9 per cent., and the average difference is ± 0.41 per cent. *Therefore, taking into consideration the atmospheric moisture, the illuminating power of the Hefner lamp can be calculated from equation I. with an average error of ± 0.4 per cent.*

The following table gives the average of observations of moisture and illuminating power for each month from April, 1894, to March, 1895. inclusive; and also the average illuminating power per month for the years 1892 to 1894:

April, 1894, to March, 1895.						Average, 1892 to 1894.
Volume of Aqueous Vapor per 1,000 Volumes of Dry Air.			Illuminating Power in Hefner Units.			Illum. Power in Hefner Units.
Average.	Lowest.	Highest.	Average.	Highest.	Lowest.	
9.14	6.91	12.05	0.999	1.012	0.980	1.007
10.29	6.98	16.37	0.994	1.009	0.959	1.000
12.31	8.93	14.83	0.979	1.005	0.959	0.990
14.43	11.48	18.48	0.970	0.988	0.948	0.978
13.35	11.94	16.50	0.972	0.981	0.956	0.977
11.07	8.16	15.43	0.986	1.001	0.958	0.988
10.44	8.51	12.52	0.991	1.016	0.977	0.993
8.87	6.13	12.11	1.000	1.017	0.977	1.002
7.18	6.05	8.18	1.009	1.021	1.001	1.010
6.11	3.27	8.24	1.016	1.033	1.006	1.014
5.25	3.18	6.95	1.019	1.033	1.005	1.014
6.77	4.71	8.13	1.010	1.022	1.002	1.011

The Hefner unit for comparison is taken at the mean value of a large number of Hefner lamps examined in the course of several years. It was found that the illuminating power was, on the average, 3.5 per cent. greater in the winter than in the summer months. In April, May, October and November, 1894, and March, 1895, the illuminating power y was nearly equal to unity. But in June to September, 1894, it was about 2 per cent. too low; and in December, 1894, and January and February, 1895, it was about 2 per cent. too high. In some months the variations are considerable. For instance, in May there are as much as 5 per cent. The lowest illuminating power found was 0.948 in July, and the highest was 1.033 in January and February; the corresponding volumes of aqueous vapor being 18.48 and 3.18. During the year the variation in illuminating power was 8.5 per cent., and the average deviation from unity was ± 1.78 per cent.

In the original definition of the Hefner unit, the atmospheric moisture was not considered. The error amounting on the average to only ± 1.78 per cent., the original definition suffices for all practical purposes. Where extreme accuracy is desired, the definition must state the amount of atmospheric moisture which corresponds to the unit value of the lamp; and since the value of the Hefner unit has been taken as the mean of a large number of observations extending over many years, the amount of moisture will be an average one. From equation I., making = 1, we find $x = 8.8$, and therefore *the Hefner unit, according to the official tests of the State Institute, is, accurately, the illuminating power of the Hefner lamp in air containing* 8.8 *volumes of aqueous vapor per* 1,000 *volumes of dry air.*

The atmospheric moisture had been estimated in these tests by an aspiration hygrometer; but a hair hygroscope, of which the deviations have been ascertained, may be used, and allowance made for these deviations. The report describes the method of using a hair hygroscope of which the errors had been determined by comparison with aspiration tests; but the example is valuable only for the particular instrument used.

Effect of Atmospheric Pressure.—From observations already made, and by plotting out observed illuminating powers, it is shown that between the limits 735 and 755 mm. (28.93 and 29.72 inches) barometric pressure, the effect of atmospheric pressure on the light is very slight. By calculation, it may be deduced that a change of 40 mm. (1.575 inches) corresponds to a change of about 4.4 per cent. in the illuminating power. Some direct measurements were made in a chamber in which the pressure of the air could be varied, and fresh air introduced at the same time. An access of pressure up to 150 mm. (5.9 inches) did not cause any perceptible alteration; and a decrease of pressure by 150 mm. resulted in a diminution of 5.3 per cent. in the illuminating power. It was evident, therefore, that changes within the limits of ordinary atmospheric pressure had not any considerable influence.

Effect of Carbonic Acid.—This was ascertained by four series of experiments. The Hefner light was measured in pure atmospheric air. The room was then aired, and carbonic acid was introduced either by degrees or at once from a cylinder. The window was subsequently opened at frequent short intervals, and the percentage of carbonic acid in the air was thus gradually reduced; while deterioration of the air through removal of oxygen, owing to the presence of two observers in the room, was also avoided. The effect of each of the contaminated atmospheres so obtained on the photometric results was observed, while a sample of the air was taken near the lamp in a 5-liter flask, and the percentage of carbonic acid in it ascertained by Hempel's volumetric method. The hygrometer was read each time.

Seventeen tests were made, the air containing from 0.6 to 13.8 volumes of carbonic acid per 1,000 volumes of dry air. If x' is equal to the carbonic acid content expressed in these terms, and y the illuminating power, the results, after correction for variations of aqueous vapor, give the following equation:

$$y = 1{,}012 - 0.0072x'$$

An alteration of one volume of carbonic acid per 1,000 volumes of air corresponds to a change of 0.0072 Hefner unit in the illuminating power, or a change of about 0.7 per cent. The amount of carbonic acid in the air of the freshly aired photometer room varied from 0.62 to 0.93 volumes per 1,000—that is to say, by about 0.3 volumes; and therefore the illuminating power in a large well ventilated photometer room would vary by only 0.2 per cent., or within the range of errors of observation. Fresh air, therefore, is all that is needed for measurements with the Hefner lamp.

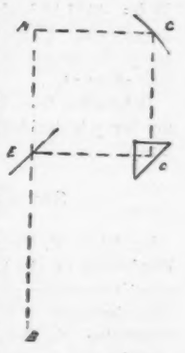
From the equations, it is evident that equal volumes of aqueous vapor and carbonic acid decrease the illuminating power unequally, or in the ratio of about 1 : 1.3. This ratio may be explained by the supposition that the decrease in illuminating power results from a lowering of the temperature of the flame through the heat taken from it to warm these diluents of the air needed for combustion. Between 0° and 200° C., the mean specific heats of equal volumes of carbonic acid and aqueous vapor are as 0.429 : 0.387, or as 1 : 1.11. According to Regnault's observations, the specific heat of carbonic acid increases with the temperature, and therefore at the flame temperature this ratio would be correspondingly increased. Though carbonic acid influences the illuminating power to a greater extent than the same volume of aqueous vapor, in reality its effect is small, owing to the small quantities, compared with the aqueous vapor, present.

Diminution of Oxygen.—That a withdrawal of a small amount of oxygen from the atmospheric air must cause a relatively great decrease in illuminating power, is evident, because such withdrawal entails a corresponding increase in all the other constituents, and especially in nitrogen. The normal proportion of oxygen—209 volumes per 1,000—being taken as a, and $a' = a - x''$ being the volumes of oxygen in 1,000 volumes of poorer air, and x and x' being the volumes of aqueous vapor and carbonic acid respectively in both cases, the a volumes of oxygen in the first case will be accompanied by $(1{,}000 - a)$ volumes of nitrogen, x volumes of aqueous vapor, and x' volumes of carbonic acid; and in the second case by $\left(\frac{a}{a'}\ 1{,}000 - a\right)$ volumes of nitrogen, $\frac{a}{a'}\ x$ volumes of aqueous vapor, and $\frac{a}{a'}\ x'$ volumes of carbonic acid. These constituents of the air are, therefore, present in the second case by the following number of volumes more than in the first case: $4.8x''$ of nitrogen, $0.0048x''x$ of aqueous vapor, and $0.0048\ x''x'$ of carbonic acid.

Let it be assumed, for the present purpose, that the nitrogen only influences the light by lowering the flame temperature through abstraction of heat. The specific heat of nitrogen would be 0.306, compared with 0.387 for aqueous vapor. Then since 1 volume of aqueous vapor per 1,000 volumes of air alters the illuminating power by 0.0055 Hefner unit, $4.8x''$ volumes of nitrogen would cause a diminution in illuminating power of $\frac{4.8 \times 0.306 \times 0.0055}{0.387}\ x'' = 0.021x''$ Hefner unit, or by about $2x''$ per cent. The increase in the volumes of aqueous vapor and carbonic acid resulting from considerable contamination and diminution of oxygen would not of itself cause 1 per cent. variation in illumination power; but a diminution of 1 volume of oxygen per 1,000 volumes of air would suffice to bring about a decrease in illuminating power of 2 per cent. Therefore a sufficiently large and well ventilated room is a first requisite for testing with the Hefner lamp. Small rooms and closed photometers cause considerable errors.

The differences between the observed illuminating powers and those calculated by equation I bear evidence of a systematic variation independent of variations in pressure, temperature, and proportion of carbonic acid. The small differences in the amount of oxygen in the air noticed by Professor Hempel may possibly account for these variations.

The diminished accuracy caused by fluctuations of the flame from side to side is due to the observer at the cathetometer being unable to perceive small movements of the tip of the flame in the direction of the optical axis of the instrument, and therefore often giving the signal when the flame is slanting. The combination shown in the accompanying figure avoids this contingency, as it allows the flame to be observed simultaneously in two planes at right angles to one another. A carrier clamped to the burner cap supports three mirrors securely fastened to one another, and arranged so that the concave reflector C produces an image of the flame A on the surface forming the hypothenuse of the prism D, while the narrow plane mirror E produces a virtual image of the real image in the same position as the flame itself. The upper edge of E is about 35 mm. (1.38 inches) above the top of the wick tube; and therefore the tip of the flame will appear through the cathetometer to be cut into two by the mirror E, and between the parts is the image of the flame viewed in the direction $A\,C$. The flame is vertical when the three parts of it in the middle of the field of vision of the cathetometer coalesce to form a continuous whole.



Experiments with the Pentane Lamp.

These were made with a lamp of the most recent pattern. The report contains an illustration and description of the lamp, which is quite familiar to our readers.[1] For the experiments, the opening opposite the flame of the lamp was set to give a light of 1-candle power. It was observed that when the tip of the flame was near the upper or the lower edge of the slot through which it is viewed, comparatively large deviations from the lighting value occurred, and it was therefore considered advisable to use the lamp with the tip of the flame near the middle of the slot only. If the flame tip passed even slightly out of the range of the slot, the deviations became very considerable. The lamp attained a state of thermal equilibrium about 30 minutes after it had been lighted, and during this time the illuminating power increased, so that the final value, at which it remained constant, was much greater than the initial. For exact measurements, the height of the flame required to be adjusted accurately as in the Hefner lamp. The flame height varies less, and thermal equilibrium is more rapidly established in the latter. Owing to the stronger draught in the pentane lamp, the flame is less easily deflected than in the Hefner lamp.

On theoretical grounds, it was found desirable to consider the light as issuing from a vertical axis parallel to the axis of the flame, and about midway between that and the cylindrical screens on the side facing the disc. If the axis of the flame were taken instead, the illuminating value would be about 1.7 per cent. greater at (say) 600 mm. (23.6 inches) than if measurements were made from the axis above defined. For the present work, this axis in front of the flame axis was taken.

Effect of Atmospheric Moisture.—Some 75 observations were made, and the results of all showed that, for quantities of aqueous vapor varying from 4 to 18 volumes per 1,000 volumes of dry air, the illuminating

1. The lamp is described in Dibdin's "Practical Photometry."

power y expressed in Hefner units, depended on the volumes of aqueous vapor x, according to the following equation:

$$y = 1.232 - 0.0068x = 1.232\ (1 - 0.0055x)$$

provided the tip of the flame was midway between the upper and lower edges of the slot.

A change in the moisture of 1 volume per 1,000 volumes of air altered the illuminating power 0.0068 of a Hefner unit, or by about 6 per cent., which was only slightly more than the alteration of the Hefner lamp. The deviation of the illuminating power calculated according to the above equation from the observed illuminating power was, on an average, ± 0.81 per cent. on the illuminating power, the greatest deviation being 1.6 per cent. These figures are about double those found for the Hefner lamp. With the volume x of aqueous vapor per 1,000 volumes of dry air, the equations for the Hefner and pentane lamps give the following ratio between the illuminating powers of the two lamps:

$$\frac{\text{Pentane lamp}}{\text{Hefner lamp}} = 1.175\ (1 - 0.0002x).$$

With all proportions of aqueous vapor that need consideration, this ratio gives nearly 1.17 in all cases; and hence the pentane lamp tested had an illuminating power 2.6 per cent. greater than the English candle, on the basis of the ratio between the English candle and the Hefner unit being 1.14, which was the mean value found by the State Institute from a large number of comparisons.

Effect of Atmospheric Pressure.—According to the observations, this was greater for the pentane than for the Hefner lamp. The following equation expresses the change in illuminating power z by a barometric change of b mm.:

$$z = 0.00049\ (b - 760).$$

If $b = 40$ (1.57 inches) then the change in illuminating power is about 2 per cent. Consequently, in measurements made with the pentane lamp, the height of the testing room above sea level should be taken into account.

It follows, from the experiments of the State Institute, that the Hefner lamp is decidedly to be preferred for testing purposes to the pentane lamp.

Saving Fuel in a Large Oil Refinery.

Dr. Chas. E. Emery, in a paper before the Am. Society of Chemical Engineers, on the topic named in the heading, says that one of the most interesting professional engagements during the past year has been the study of conditions obtaining in the large oil refinery of the Tidewater Oil Company, at Bayonne, N. J., with a view of recommending means to obtain a saving of fuel. An incredibly large amount of steam is required in such a place. It is used for power to operate the engines for the various manufacturing establishments—such as barrel, can and box factories; to operate steam pumps to transfer the oil and finished products to different parts of the yards; to press out the paraffine or wax from the heavier oils; to operate hydraulic presses for higher pressures; to pump water in large quantities for cooling purposes, ammonia for refrigeration, etc. Some steam power is also required for electric lighting. A very large part of the steam supply is, however, required for various heating operations connected with refining.

In the refinery referred to there were 5,500 horse power of boilers, installed in four boiler houses in different parts of the grounds, which boilers were originally forced much beyond their capacity a great deal of the time. The coal consumption for steam purposes amounted to about 64,000 tons per year, independent of which a very large quantity was consumed directly under oil stills. The question of the saving of fuel had been agitated before the writer was consulted, and some savings made by separating the boilers for two different departments in the refinery, so that each could be held responsible for its own consumption. It had also been considered that there were some connections between the different boiler houses which could be simplified, as it had been found necessary to keep all the boiler houses in operation nearly all the time.

The executive officers had also entertained a proposition from the prominent electric companies to erect a central electric plant for generating alternating current, it being proposed to substitute alternating motors for all of the steam engines in the establishment, of course putting in new pumps adapted for operation in this way. The cost seemed so large that the writer was consulted as to the best method desirable under the circumstances.

It was found that the executive officers at the refinery had studied the problem very thoroughly, and that they knew in a general way the causes of the large consumption of steam. One of them had, some time before, sent to the writer for a copy of experiments which he had made on the cost of steam power with ordinary steam pumps, which led to an investigation of the cost of power with the large pumps of the refinery, the method generally adopted being to ascertain the weight of exhaust steam delivered through a temporarily arranged surface condenser, or, in some cases, the extra weight caused by exhausting directly into a vessel of water, the water used being compared directly with the theoretical power obtained from the gallons pumped and the pressure of delivery.

It was found that many of the steam pumps were using as high as 240 pounds of water per net horse-power per hour, and only in exceptional cases could one be found which could deliver a horse-power with as low as 80 pounds of feed-water. The general impression seemed to be that the steam pumps were requiring, on the average, 150 pounds of water per horse-power per hour. The advantages of using exhaust steam were also appreciated to a certain extent, as exhaust steam pipes were being erected and connected so as to keep the various stills and tanks warm during the winter.

The preliminary report of the writer, which was not based on full knowledge of all that had been done before, corroborated the opinion of the officers as to the causes of the large consumption of steam, but considerably modified the suggestions as to the methods of reducing the same. The large electric plant was not approved. A smaller electric transmission was recommended to reach various outlying points where steam had to be transmitted a long distance at very great expense in condensation, independent of the power developed, since it was necessary in winter, and desirable in summer, to keep the pipes warm all the time, although the power was, at many of the points, used only occasionally.

An extension of the exhaust system was recommended even if it became necessary to increase the back pressure, and it was recommended that a number of power stations be established in which would be erected good high-pressure non-condensing engines operating power pumps to take the place of the numerous steam pumps in different parts of the works, the exhaust from such engines to enter the exhaust mains and to be used for heating purposes. It was pointed out as desirable that the changes be made somewhat slowly, so that experience gained at one plant could be applied at another, and so that the class of engine best adapted for the purpose could be determined. Evidently, if all the exhaust would eventually be required a cheap form of engine could be used, and, if the contrary was the case, good compound condensing engines could be used at some of the locations.

The suggestions were adopted, and considerable work has been done under the immediate directions of the executive officers in consultation with the writer. At the present time the system of local plants operated by high-pressure steam engines and power pumps has been applied at two points in neighborhoods where the least exhaust steam is required, and the exhaust steam from nearly all the engines and the large number of wasteful pumps has been collected and used at a pressure of about 10 pounds in the steam stills, the result showing that nearly all of it could be utilized.

The result of the work thus far accomplished has been to reduce the coal consumption for steam purposes fully one-half, or about 32,000 tons per year. The saving has grually increased from the time the work was commenced, and has been 54 per cent., compared with the previous year, for the last three months, though the entire work laid out is not yet complete. One of the four boiler houses has been closed, and experiments are in progress to ascertain how many more boilers can be shut down without forcing the remainder above the economical limit.

The principal part of the saving has been due to the use of exhaust steam. Its application in steam stills required experiment, so the results could not have been accomplished without the hearty co-operation of the executive officers of the establishment. Before the changes the yards were overhung by clouds of escaping steam; now hardly any is visible. In comparison, it seems like Sunday, or as if the work were stopped, whereas, actually the output is, at times, greater than before, The fact that so much exhaust steam could be utilized has somewhat modified the original plan of dispensing with all the steam pumps. At points where there is little condensation due to exposure, evidently the lack of efficiency is of minor importance, as the heat passes on and is utilized for heating purposes. In outlying districts, however, there was a large amount of condensation in pipes and pumps, necessarily located out in the air in many cases, to avoid danger from fire. A number of these pumps have been housed so as to save loss by condensation, and power pumps will be substituted for others in another sub-

station, thus reducing the surplus of exhaust steam, when improvements will be stopped for a time until experience indicates the desirability of further change.

The question may be asked why it was decided to give up the electric-power system. The principal reason was that it was quite expensive, and, moreover, not warranted by a balance of the advantages for a location where much of the exhaust steam could be used for heating purposes. Even if interest on first cost were neglected, the quantity of exhaust steam which could be utilized for heating purposes would be many times as much as the steam required to operate the dynamos. This last steam had to be supplied as well as the first, and, if supplied through steam engines, the power could be developed with only the extra cost due to heat lost in the performance of work, which is comparatively trifling in such a place, and the heat lost by radiation during transmission. So long as the heat lost by radiation was less than the cost of the power in the best compound engines, the use of the latter was not warranted even on economical considerations, and when the cost of the electric plant was considered, the balance was decidedly in favor of the plant finally decided upon. It does not follow that this decision would apply as a general rule. Every case must be decided on its own merits, but in making such decision great pains must be taken to obtain the probable results in practice rather than those which have been shown under experimental conditions.

The small electric transmission plant previously referred to is now in operation. It is a three-phrase alternating system, put in by the General Electric Company. A 75 kilowatt, 550 volt generator is provided, it having been decided on consultation, to make it large enough to furnish all the incandescent lights then supplied from three small plants in different parts of the yard. There are about 60 horse-power of motors distributed at outlying points, the units varying from 5 to 30 horse-power. The electric conductors displace about 2,000 feet of steam pipe of various sizes, which it was necessary to keep hot winter and summer. In locations where gases exist that a spark would light, the variable starting resistance has been omitted from the motors, and the switch-blades are immersed in oil, so that the electric apparatus is absolutely sparkless. The change has improved the electric lighting, and the motors are also operating quite satisfactorily.

The Vulcan Combination Boiler.

Messrs. William M. Crane & Co., of this city, who are quite well pleased over the favor with which the Vulcan combination boiler has been received, recently wrote us respecting its merits. They assert, in fact, that the Vulcan combination boiler has fully solved the hot water problem, and solved it in a most economical manner. The boiler can be connected in the same way as the ordinary range boiler is connected to a coal range, thus taking the place of the old boiler; but the construction is such that when the coal range is not in use hot water can be obtained at once by simply lighting up the gas attachment, making practically an instantaneous water heater, with the advantage that hot water can be drawn from any part of the house supply.

Hot water can be obtained from the use of the coal range independently, or from the gas, or from both at the same time, without necessitating any change whatever since no stopcocks are used, and perfect circulation is obtained, whether the heating agent is either gas or coal.

Referring to the illustration, the coil within the boiler forms a complete water back, which can be utilized at will by lighting the burner and not in the least interfering with the circulation to the water back in coal range. When hot water is drawn, the ball which closes the inlet is forced up and shuts off the passage to the outlet, thereby preventing cold water from being drawn direct, as all the water is then forced through the coil connecting at the top of the boiler and becomes heated in the circulation of the coil. A perfect circulation is obtained, whether gas or coal is used for heating, the action being independent in either case, while at the same time neither one interferes with nor checks the other.

The coil is made of one-half inch seamless copper tubing, and extends the full length of boiler. It is confined in an iron casing which conveys all the heat from the gas burner close to the coil, and all products of combustion can be carried off from the top of the boiler by means of a 3-inch pipe connected with any flue. The boiler is heated by the coal range on the ordinary principle. The capacity of the boiler is 30 gallons.

Wire Rope Haulage, Its Use and Abuse.

[Read by Mr. T. E. Hughes, M.E., at the January meeting of the Ohio Institute of Mining Engineers.]

For underground haulage, there are to-day, generally speaking, three systems in operation in the bituminous coal regions of this country: 1st, the tail rope system; 2d, the endless rope, and 3d, the electric system. Each system has its good points as well as its weak ones; and no engineer or coal operator should let any influences have a bearing upon which method he will adopt other than those produced by the conditions as he finds them at his particular plant.

A general rule to be observed by all as to the manner of operation would be one of the worst things to meet with in coal mining. Let me right here quote literally from an article read before the mining engineers of Western Pennsylvania, as follows: "It is very essential in deciding which system of mechanical haulage is best adapted to any particular mine, to carefully consider all the conditions to be contended with."

This vital point that is here reiterated covers the true secret of a successful haulage system, be its manner of operation what it may. Hence you will see that any remarks of the author of this paper will have to be considered in a general way, produced by observation of various plants working under very dissimilar conditions, and the suggestions being of a general nature and not applicable to any particular plant until first the conditions of said plant have been carefully studied out.

Generally speaking, a tail rope system produces more satisfactory results than the endless rope system. First, we can use a tail rope system in single gangways by carrying the tail rope between the tracks, alongside the track or overhead. An endless system, generally speaking, calls for a double gangway to produce economic results—*i. e.*, the carrying in of empty cars at the same time the loaded ones are being taken out. This is the first reason why the writer would advocate, where the plant admits of so doing, the use of a tail rope system.

The next reason, and it cannot be considered too carefully, is the objectionable feature of the endless system—*i. e.*, friction. Friction, reduced down to mechanical results, means nothing more nor less than wear and tear at points of contact; and if said friction or wear and tear must produce the moving or grasping the load we propose carrying, it certainly means wear and tear of something, at some point.

There are several methods of fastening to or attaching the loaded train of cars to the endless system, one being two pulleys mounted on a small truck, each nearly touching the other at the face of said pulleys or sheaves when out of service, the shafts carrying these two pulleys being connected together by a right and left hand screw. When said screw is revolved it widens the distance between the pulleys, and the endless rope being passed around said pulleys, becomes taut, friction accrues, and eventually by friction the rope takes a permanent grip on the pulleys and the train is moved.

Another system, and one more commonly used, is to mount on a small truck a device working on the principle of a vise operated by a screw. This, again, by the closing of the vise, makes contact with the rope, which, when the friction has been overcome, makes the attachment a permanent one, and the load moves.

In operating a wire rope, be it for haulage or other purposes, avoid friction as you would poison. If for no other reason, I would, at all times, advocate putting in a tail rope system for the foregoing reason, even if no other reasons or conditions warrant so doing. A tail rope system, properly put in, with a boiler capacity and power of engines being 25 per cent. in excess of any possible requirements, will, in nine cases out of ten, produce the greatest result for the capital invested.

It may have occurred to some of you by this time that I have not referred to the fact that a tail rope system calls for about 50 per cent. more

rope than an endless system. True; but actual experience by the rope makers, I think, will demonstrate the following to be a fact: Conditions being equal, two plants side by side, going into a heading 10,000 feet from the power house, with a tail rope system calling for 30,000 feet of rope, and another with an endless system, like distance and under like conditions, if such a plant ever existed, would result in the tail rope lasting twice as long as the endless rope, producing a saving of 33 per cent. on rope bills, where 50 per cent. more rope is in operation—this coming from the necessity of replacing the endless rope twice as often as the tail rope.

Let me now refer to one or two tail rope systems working under favorable conditions that have produced very satisfactory results, and, in a general way, could and should be duplicated anywhere in the United States where the coal to be handled would warrant the investment.

First, there is a plant within 25 miles of Pittsburgh, operating the tail rope system, the length of haul being 10,500 feet. This, as you see, calls for 10,500 feet of main rope and 21,000 feet of tail rope. Their engines are 14 x 24; drums, 6 feet in diameter. They work under 80 lbs. steam pressure; they haul a maximum of 90 cars per trip, loaded as follows: Coal, 4,000 lbs.; tare, 1,500 lbs.; gross, 5,300 lbs. There is but little gradient, and that is a maximum of 1½ per cent. against these empty cars—that is, in favor of the loaded cars. They make 16 trips, and it takes 40 minutes to make a trip. The engines are geared four to one. They use for the track a 30-lb. steel rail well ballasted. Rollers are 20 feet apart. The roadbed is on a coal bottom, under which is a hard fireclay, and under this fireclay a limestone. This, as you will see, gives what might be termed an almost ideal condition for a roadbed in a coal mine. The mine is well drained to the opening or openings.

Again, I have in my mind's eye a plant within 200 miles of Pittsburgh. The engines are 20 x 30; they are geared three to one; they develop 450 horse power while hauling the trip of 40 cars up a grade of 1 in 20. The gross tonnage of load is 234 tons 880 lbs., divided as follows: Coal, 160 tons; cars, 60 tons; weight of rope, 14 tons 880 lbs. The haulage is 9,000 feet from the heading to power house. They use a 1¼-inch hauling rope, and a ¾-inch tail rope. One of the main ropes on this latter plant is still in service, and its mate was taken off this last summer. I forgot to state that this is a double tail rope system. The main rope and tail rope taken off last summer hauled 1,200,000 tons of coal. Consequently you will find, by a short process of figuring, the cost of the rope per ton of coal hauled.

The plant first referred to does not have any conditions of grade to speak of; in other words, the maximum grade is 1½ per cent. in favor of the load. They have hauled out over 1¼ million tons of coal with 30,000 feet of ¾-inch crucible steel haulage rope, costing as you will see 2, 4-10c. per 1,000 tons for haulage.

Having now referred to a couple of plants hauling coal with favorable commercial results, I now want to switch back again to general conditions to be observed for operating rope haulages, be they endless or tail rope. Perhaps one of the most vital and beneficial changes that our engineers have made is that where we have to make a turn in our gangway at a right angle (or nearly so), they now, whenever it is possible, introduce the reverse curve to overcome the strain resulting from using a guide wheel or carrier. By using the reverse curve, you can see at a glance, we get a much greater radius, and naturally much less bind or set in the rope, than under the old conditions. Observe that the mine engineer will reverse the conditions of the steam railway engineer in the following way: Your inside rail must be elevated above the level of your outside rail, owing to the fact that the pull of the rope will have a tendency to increase friction if the rails are on a level, while on the contrary it is a question of momentum to be overcome when a railroad engineer of a steam road elevates the outside track instead of the inside, as the mining engineers do.

It will not do to leave the discussion without noticing another important factor in a well equipped plant, the kind and construction of the rope that you use. The kind most commonly used for haulages is composed of six strands of seven wires each laid around a hemp center. The wires, generally speaking, are of steel. A rope that has received more attention than it merits is what is known as the "Lang-Lay" rope. This rope is composed of the same number of wires and strands as the commonly used haulage rope, but differs in this respect. The strands when being twisted together are being twisted in the same direction as the wires have been in each particular strand. This produces a much more flexible rope than the rope made in the way known as a standard lay. The strands in the standard laid rope are laid up in the opposite direction to the lay of the wires in the strand.

A flexible rope is a desirable one, if we do not sacrifice some element of vital force equal to or greater than what we gain in flexibility. There are exceptional cases (which the discussion of this paper may bring out) in which the lang-lay rope is the most advisable, but generally speaking the lang-lay rope does not give as good service as the standard lay.

By examining a section of a lang-lay rope, you will see that the wires run over the pulleys at an angle of about 45 degrees. If every pulley is in an ideal condition, *i. e.*, running true, well lubricated, and in first-class condition, the construction of the rope will not make a material difference in the life of the same, but, are these condition ever lived up to? We say "no;" consequently, at just exactly the ratio of the condition of the passing from the ideal to the actual, at that ratio does friction come in in the wear of the wires on the lang-lay rope over and above what would be the case with the standard lay.

To further illustrate this, you will notice that when a mechanic is using a file in filing a piece of metal, he takes the position of the file at exactly the same angle at which these wires are laid to produce the best results, *i. e.*, the angle that will cut or wear away the metal to the greatest amount with each stroke of the file. If the mechanic will do it with that object in view, does not the same result follow with the lang-lay rope, when passing over the pulleys full of grit and dirt. Such being the case, rope manufacturers, generally speaking, recognizing this fact, have insisted on the use of the standard lay rope to produce the best results for the operator. You will notice in the standard lay rope, that the wires lie parallel with the motion of the rope, and for this reason, when passing over pulleys expose the smallest amount of surface of each wire for friction that is possible, and by so doing has a tendency to slide over the pulleys rather than scrape them.

Again using the file for an illustration; if you put the file in the mechanic's hand, and tell him to push it over the metal he is filing, with the teeth of his file parallel with the motion of the stroke, he will at once tell you that his file will slide over the material instead of cutting it. This illustration will best serve my purpose, in indicating why the lang lay rope will not give as good service, generally speaking, as the standard lay. There are, as I have intimated, exceptional cases where the lang-lay rope will work, but only exceptional, they being, perhaps, controlled by the following conditions: A high speed motion, very small drums, and numerous angles in the operation of the plant.

Under these conditions perhaps it might be advisable to use the lang-lay, on account of its extra flexibility over and above the ordinary haulage rope made of seven wires to the strand; and even in this condition, it is a question which only a rope manufacturer should decide, as to whether a rope made of 19 wires to the strand, standard lay, would not give better service than a rope made lang-lay seven wires to the strand. This illustration once more forces upon us the fact that friction is an expensive luxury, and only those who need not care what the expense of the luxury is should ignore its cost.

Before leaving the subject of haulage, we might be considered behind the time if we made no reference to the latest development, namely, electric haulage. Electric haulage, as being introduced to-day, means haulage by traction; and, getting back to our old hobby again, traction means friction. The problem—a simple one—is, to move a given load (the power needed it is presumed we have at our command) by a sufficiently heavy motor to give us the required traction, in other words, sufficient to reduce the friction between the motor wheels and the rail to nil. This, after careful investigation, I am firmly convinced has, as yet, not been successfully accomplished, looking at the question of commercial economy and success.

Of course, I realize that this remark will bring down upon my unprotected head an avalanche of criticism from our electrical engineers, yet, I will frankly say right here, that if I am mistaken, I am as anxious as they are to see the error of my ways, and only too gladly will make due apologies, and concessions for such discrepancies as they may point out to me. But, as I now see it, there is not in operation to-day, to my knowledge, an electric hauling system giving the desired mechanical results, that I would not be willing to guarantee to exceed said mechanical results on less than 75 per cent. of the capital invested in the electric installation, by substituting wire rope. If this is so, electricity is as yet, economically speaking, a failure.

Let me close these remarks by suggesting that some of the rules that are given us for success, when seeking happiness, will apply with equal force in seeking coal: Avoid friction. Take the best of care of the health of your plant. See that all things work in harmony. See that the joints are well lubricated. See that each part of the plant performs its particular duty. See that it gets the daily care that it should have to enable it to do to-morrow's work as ably as it did to-day's, and rest assured it will live to a ripe old age, and make all happy who come in contact with it.

ITEMS OF INTEREST FROM VARIOUS LOCALITIES.

FROM the report of Chief Engineer Park, to the Director of Public Works of the city of Philadelphia, respecting the operations of the Gas Bureau for the last year, the following is gleaned:

Sales of gas, tar and coke	$3,092,589.94	
From rents	621.52	
Rent of purifying house, Richmond district	5,000.00	
Stock of coal on hand	66,913.16	
Stock of coke on hand	23,625.82	
Due for gas sold, and value of stock in hand	655,074.90	
Due for residuals, etc	12,203.85	
Material on hand, etc	25,857.27	
		$3,871,886.46
Coal and coke on hand	$138,272.44	
Due for gas and coke	644,294.32	
Due for residuals	14,882.24	
Materials on hand	62,758.75	
Payments, account manufacture	1,449,251.84	
Payments for gas purchased	600,000.00	
Repairs to works	288,781.71	
Miscellaneous, salaries, etc	389,055.60	
Profit for year	284,589.56	
		$3,871,886.46

The gas manufactured during the year was 4,422,752,000 cubic feet, of which 2,728,665,000 cubic feet were made by the city, and the balance was purchased from the operators of the water gas plant at the 25th ward works. The total quantity of gas made since the works were started was 80,190,630,000 cubic feet. Of the gas manufactured by the city in 1895, the output at the different stations was:

25th ward	375,952,000 cubic feet.
Point Breeze	1,389,228,000 "
Ninth ward	962,885,000 "

The average daily production was 12,117,128 cubic feet, as compared with 11,261,372 cubic feet in 1894. There were 286,797 tons of coal carbonized during the year, the average yield of gas therefrom being 4.76 cubic feet per pound carbonized, and the average candle power of the product was 19.04. Of the gas produced, 2,744,496,000 cubic feet were delivered to private consumers; 520,707,106 cubic feet were consumed in the street lamps; 26,895,700 cubic feet were taken by the city public buildings; the almshouse absorbed 20,113,500 cubic feet, and 15,964,100 cubic feet were used in the public schools. The quantity charged to leakage, or as unaccounted for, was 102,140,315 cubic feet. There were 6,535 meters and 7,106 services added during the year, the number of each in use now being: Meters, 160,082; services, 204,126.

THE proprietors of the Florence (Ala.) Gas Light and Fuel Company have authorized Superintendent Baum to announce that hereafter those who pay their bills promptly (on or before the 5th of the month) will be supplied at the rate of $2 per 1,000 cubic feet, which is in effect a concession of 50 cents per 1,000 from the old rate. The Company has also completed an addition to the capacity of its carbonizing plant.

THE plant at Phœnix, Ariz., is to be reconstructed. It will stand such an operation.

THE electric light suppliers at Rahway, N. J., early this month, put a new selling schedule in force, the results of which are peculiarly satisfactory to the local Gas Company. The electric schedule shows an increase of about 80 per cent. in the instance of an incandescent lamp service, and Superintendent Horton just now is busy connecting up old services and putting in new ones for those who wish to "do business" with the Gas Company.

JUDGE MITCHELL, of the Minnesota Supreme Court, has pronounced against the Stillwater Gas and Electric Light Company, in the case recently argued before the court, and indexed as, "Jas. Matthews, respondent, vs. Stillwater Gas and Electric Light Company, appellant." A syllabus of the opinion is appended:

"Action to enjoin the maintenance of a nuisance caused by the escape of nauseous and offensive gases from a gas plant, and smoke, cinders and soot from an electric light plant, owned and operated by defendant, into and upon the adjacent premises of the plaintiff. That part of the plant constituting the gas works had been operated by defendant for 15 years, but had been enlarged and the mode of making gas changed within that time. That part of the plant constituting the electric light works had only been built and operated about 8 years. The plaintiff did not object to the construction of the works while they were being built, but ever since they have been operated has continuously objected to and remonstrated against the acts creating the nuisance. Held, that the plaintiff is not estopped by his conduct from objecting to the continuance of the nuisance. Also, that defendant has not acquired a right by prescription to maintain the nuisance. To constitute an adverse use requisite to maintain a right by prescription to maintain a nuisance, the nuisance must have been continued in substantially the same way and with equally injurious results for the entire statutory period. Judgment affirmed." The Company will appeal.

IT is understood that the San Francisco Gas Light Company will purchase the property of the Young Men's Christian Association, which site is well situated to further the object the Company has in view—a desire to have its offices in a central location. The Association's land and buildings are on Sutter street, near Kearney, a location in every way vastly more desirable than the present First and Howard street position of the Gas Company's office possessions. Of course the building will have to be remodelled to meet the Company's needs.

WRITING of the San Francisco Company reminds us that at their annual meeting the shareholders named the following Directors: Joseph B. Crockett, Adam Grant, George W. Prescott, Levi Strauss, A. H. Payson, Daniel T. Murphy and J. Downey Harvey. Subsequently the Directors named the following officers: President, Joseph B. Crockett; Secretary and Treasurer, W. G. Barrett. The Company had a prosperous year, a feature thereof being the success which followed the greater attention given to pushing the use of gas for purposes other than illumination.

MR. CHARLES J. LUTHER has resigned the position of Superintendent of the Long Branch (N. J.) Gas Light Company, owing to the recent absorption of that plant in the system of the Consolidated Gas Company, of New Jersey.

AT the postponed annual meeting of the shareholders in the Little Falls (N.Y.) Gas Light Company the Directors chosen were: Capt. W. Henry White, Fred. I. Small and E. P. Callender. The Directors subsequently named the following executive management: President and Treasurer, Capt. W. Henry White; Vice-President, Fred. I. Small; Secretary and Superintendent, E. P. Callender.

LAST week we reported the formation of the Standard Gas Company, the field of operation of which was said to be Montreal, Canada. The purpose of the Company, however, is merely to exploit upon the Canadian market air gas machines of the type known as the "Lawrence Gas Mixer and Atomizer." The machines are protected by Canadian letters patent, numbered 44,943.

LAST month the proprietors of the New Haven (Conn.) Gas Company forwarded to Chief Kennedy, of the New Haven Fire Department, a check for $100, the proceeds of which are to go into the treasury of the Firemen's Relief Fund. The donation was prompted by the clever work performed by the firemen during the conflagration on Crown street, New Haven, which followed that explosion brought about by the experiments of some amateurs with acetylene gas. At one time it looked as if the flames would reach the Gas Company's office building, but Chief Kennedy and his men saved the premises.

AT the annual meeting of the St. Thomas (Canada) Gas Company the Directors chosen were: J. Farley, J. H. Still, M. A. Gilbert, D. K. McKenzie, John Baird, J. N. Scatcherd and J. C. Duffield. The Directors then named the following officers: President, J. Farley; Vice-President, J. H. Still; Secretary and Treasurer, M. A. Gilbert.

A CORRESPONDENT at Manchester, N. H., writing about the annual meeting of the Pittsfield (N. H.) Gas Company, which concern manufactures a naphtha gas of doubtful quality, and which he asserts would find it beneficial to overhaul its plant, says that after Mr. C. H. Carpenter had been elected President and Mr. N. S. Drake had been appointed Clerk, a lively discussion "followed a proposition to reduce expenditures by the consolidation of the offices of Treasurer, Collector and Superintendent, some of the members contending that the duties thereof could easily be performed by one man, thus making a substantial saving to the Company. The dissatisfaction seemingly was based on the fact that the receipts for 1895 were larger than those of any other year in the Company's trading, still the net income was insufficient to permit the payment of a dividend. The officers retorted that the increased expenditures were largely due to extraordinary expenditures on account of the wear and tear of former years. The matter was finally compro-

mised by consolidating the offices of Treasurer and Collector, and Mr. J. A. Goss was appointed to the dual position. Mr. C. H. Lane was appointed Superintendent. The report for the year showed that while the gross output and the number of consumers had each been increased, the consumption per capita was less than that of the year 1894."

THE new gas rate at Charlotte, N. C., shows, for an illuminating use, a maximum price of $2 per 1,000 and a minimum of $1.50 per 1,000, according to the monthly consumption. The rate for fuel purposes is: Maximum, $1.60 per 1,000; minimum, $1.30.

"OBSERVER" forwards the following: "The reduced rate for gas at Norwich, Conn., took effect on the 1st inst. Substantially, the terms are these: For illuminating purposes, $2 per 1,000, with 5 per cent. off for prompt payment (within 10 days) on monthly bills of $10 and under; 10 per cent. off on bills over $10 and under $20; 20 per cent. on bills of $20 and upward. The fuel rate, for gas so supplied through special meter, $1.40 per 1,000, with 10 per cent. off for prompt payment. The Company proposes to keep a full line of gas cooking and heating apparatus, suitably displayed in its Shetucket street offices, and will dispose of the goods at net cost to itself. While we all regret the changed conditions of the Company that necessitated the retirement of Mr. Gillmor from the Superintendency, it is nevertheless a fact that Mr. Samuel Hurlbut, the present Manager, is a wideawake and thoroughly competent man."

WE understand that the Common Council, of Cripple Creek, Col., has voted a 30-year franchise for the operation at that point of a gas works to George M. Meyers and his associates, of Kansas City, Mo. The Company may charge a maximum rate of $3 per 1,000 cubic feet. The syndicate represents the American Incandescent Gas Company, and it is regrettable that Cripple Creek did not make a wiser selection.

AT the annual meeting of the Waterbury (Conn.) Gas Light Company no change was made in its official management. The special business of the meeting was to consider the matter of accepting the privilege granted by the last Legislature in the form of an amendment to the Company's charter, under which authority has been given to it to lay pipes, etc., outside the limits of the city, in the town of Waterbury. Also, to authorize the Directors to execute a lease of the lot and buildings thereon, recently acquired, to the United Gas Improvement Company, in order to more fully carry out the provisions of the lease now in force. Both provisions were affirmed.

IT is believed that a gas plant will be constructed at Argentine, Kas., by those interested in what is known as the Hoag combination.

ADVICES from Louisville, Ky., are to the effect that the City Council of Henderson, Ky., has awarded a contract for the rebuilding of the generating system of the Henderson City Gas Works to the Parker-Russell Mining and Manufacturing Company, of St. Louis, Mo.

AT the annual meeting of the Equitable Gas and Electric Company, of Utica, N. Y., the Directors chosen were: W. T. Baker, John Fox, H. Keene, J. P. Miller, Casimir Tag, E. J. Jerzmanowski, H. Gebhard, A. R. Pick and E. Balthasar. The Directors named the following officers: President, Casimir Tag; Vice-President and Treasurer, H. Keene; Secretary, J. P. Miller; General Manager, E. A. Pinkney.

MR. HARRY S. MORGAN, formerly with the Chicago Gas Light and Coke Company, has accepted a responsible position with the Excelsior Coke and Gas Company, of Topeka, Kas.

THE Salem (Mass.) Gas Company will hereafter occupy the entire lower floor of the building of the Peabody Academy of Science for its business offices. This will guarantee a fine display room for ranges, heaters, etc.

THE Berlin Iron Bridge Company, of East Berlin, Conn., has just completed a very successful year. The shipments, which were the largest in the history of the Company, represented a money value somewhat in excess of 1½ million dollars. At the annual meeting of the shareholders, which was held at the office of the Company, Thursday, January 30th, the following Directors were elected: Chas. M. Jarvis, Burr K. Field, Geo. H. Sage, H. H. Peck (Waterbury, Conn.), S. H. Wilcox (Brooklyn, N.Y.), J.W. Burr and F. L.Wilcox. At the meeting of the Directors the following officers were elected: President and Chief Engineer, Charles M. Jarvis; Vice-President, Burr K. Field; Secretary, George H. Sage; Treasurer, F. L. Wilcox; Manager of Highway Bridge Department, D. E. Bradley; Assistant to the President, E. W. Stearns.

THE "accidental" Mayor of Louisville, Ky., is anxious to remove Mr. John Breeden from the position of official gas inspector, so that some active working Republican may receive the emolument of the office, which amounts to $3,000 per annum. Meanwhile, Mr. Breeden is undisturbed, since under the ordinance creating the position the tenure thereof is four years, and removal can be made for cause only—which Mr. Breeden is not the sort of man to furnish in his administration of official duties. Mr. Breeden was appointed in 1894 by the late Mayor Tyler.

MR. WM. M. LOWMAN, who has been acting as temporary receiver for the Hastings (Neb.) Gas Company, has been confirmed permanently in the position by order of Judge Beall.

AT the annual meeting of the Hoosick Falls (N. Y.) Gas Light Company the following result was reached: Directors, Danforth Geer, Willis E. Heaton, C. E. Dudley Tibbits, Charles A. Cheney and Geo. E. Wilcox; President, Danforth Geer; Vice-President, Willis E. Heaton; Secretary and Treasurer, Chas. A. Cheney.

THE proprietors of the Holyoke (Mass.) Gas Works have awarded a contract for a complete set of water gas apparatus to Messrs. Humphreys & Glasgow, of this city. The plant is to be up to manufacturing 500,000 cubic feet of gas per day.

MR. J. A. MCCOLLUM, the clever Superintendent of the works of the Riverside (Cal.) Gas and Electric Light Company, has perfected an apparatus for the distillation of crude oil from the Los Angeles district.

THE Wayne (Pa.) Electric Light Company's plant was entirely destroyed by fire on the morning of the 1st inst. The loss is estimated at $45,000, but the insurance companies are the sufferers, since the property was fully insured. This mention brings up the idea that Wayne, which is virtually a suburb (and a beautiful one) of Philadelphia, ought to have a Gas Company; for in close proximity to it are the towns of Radnor, Berwyn, Strafford, Villa Nova, St. Davids and Devon, all of which are residential districts of a high class.

THE annual meeting of the Joliet (Ills.) Gas Light Company, which was held towards the close of last month, shows that Mr. I. C. Copley, of Aurora, Ills., and his friends are now in control at that point. The officers chosen were: President, W. W. Tracy, of Springfield; Secretary, Fred. Beenitt, of Joliet; Treasurer and General Manager, I. C. Copley, of Aurora. Mr. Ward Elwood, who has been Superintendent at Joliet for some time, tendered his resignation, and his successor has not been appointed, although the foreman of the Aurora works (which is also controlled by Mr. Copley, under whose administration its expansion has simply been remarkable) is temporarily in charge. Mr. Arthur Bush will have charge of the office work. The plant, which is in fairly good shape, will be thoroughly overhauled, and a new station meter has been ordered for it. The main system will be extended in all directions, the plan in this respect under consideration involving the laying of about 30 miles of new mains in the next three years. In fact, pipes will be laid wherever there is a demand for gas, and when that demand is lacking in districts where it should exist, inducements will be offered to encourage it. A particular effort will be made to popularize the use of gas for cooking purposes, and that it will avail is quite certain when it is said that Mr. Copley has on his list of users of gas for purposes other than illumination in Aurora no less than 1,140 names. He is sure to succeed at Joliet, for he has system, energy and liberality in his way and method of working.

LAST month, during the prevalence of a severe electrical storm in Haywards, Cal., a stroke of lightning completely destroyed the dynamos of the Haywards Electric Light Company. The ruin was complete.

THE Directors of the Galesburg (Ills.) Gas and Electric Light Company have named the following officers: President, Howard Knowles; Secretary and Treasurer, J. K. Mitchell.

THE Directors named by the New York and East River Gas Company for the ensuing year are: August Belmont, Charles F. Cutler, Frederick Cromwell, G. G. De Witt, Robt. Goelet, R. Somers Hayes, Jacob Hays, H. B. Hollins, E. Lehman, Robert Maclay, H. H. Rogers, John C. Tomlinson and R. T. Wilson.

THE AMERICAN GAS LIGHT JOURNAL

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MONDAY, FEBRUARY 10, 1896.

The Market for Gas Securities.

Continued firmness ruled during the week in the city gas share market, the feature being a sharp rise in Mutual, which is bid for at 237. From the present standing of the Company, judging either from its value for purposes of amalgamation, or as an independent factor in the gas supply of this city, we have slight hesitation in asserting that Mutual ought to in the near future sell at 275. Equitable also scored a sharp advance to 208½ to 212. The movement in Consolidated was less pronounced, but firmness ruled in it throughout. New York and East River common, and the Standard Company's shares were decidedly higher. The legislative mill so far has developed nothing that looks dangerous in the shape of a rate bill, although it is true that two of the measures might be expensive. The State Inspector of Gas Meters, Mr. Stewart, has shown his fine "machine" hand in the appointment of Joseph Stockmar for the Buffalo deputyship, and the Albany one went to Joseph Pauly of that city. This leaves the Brooklyn place still unsettled, although it is said that ex-Senator Owens will surely succeed the present incumbent, Mr. Hennessey. Another evidence of the fondness of the legislators for tinkering with the gas meter question is shown in the bill introduced last Thursday by Assemblyman Austin, at the instance of Inspector Stewart. It provides that the Inspector may at any time, when he finds his duties becoming onerous, appoint a special deputy in any county, for such length of time as he deems expedient and at such rate of compensation as he thinks advisable. It is a bald, bad bill, but its passage means a comparatively cheap way of adding another obligation to the politicians by the gas companies.

Agents of the Brooklyn Union Gas Company have purchased about seven-eighths of the shares of the Flatbush Gas Company, at a price somewhere in the neighborhood of 120; and they got a bargain. Brooklyn Union shares are steady, at 78 to 79.

The Chicago rehabilitation proceedings are in a shape satisfactory to the syndicate in control, and our belief is that the shares are a purchase.

Baltimore Consolidated is wobbly, at 55½ to to 56; and Consumers, of Jersey City, is steadily improving.

Gas Stocks.

Quotations by Cochran & Close, Brokers and Dealers in Gas Stocks.

35 WALL ST., NEW YORK CITY.

FEBRUARY 10.

☞ All communications will receive particular attention.
☞ The following quotations are based on the par value of $100 per share.

N. Y. City Companies.	*Capital.*	*Par.*	*Bid.*	*Asked.*
Consolidated	$35,430,000	100	155½	156½
Central	500,000	50	150	..
" Scrip	220,000	..	100	.
Equitable	4,000,000	100	208½	212
Bonds, 6's	1,000,000	1,000	105	..
" 1st Con. 5's	2,300,000	1,000	114	.
Metropolitan Bonds	658,000	..	108	112
Mutual	3,500,000	100	227	..
" Bonds	1,500,000	1,000	100	102
Municipal Bonds	750,000	..	..	.
Northern	150,000	50	79	80½
" Bonds	150,000	1,000	..	98
New York and East River	5,000,000	100	37	39
Preferred	2,000,000	100	68	73
Bonds 1st 5's	3,500,000	1,000	98½	100½
" 1st Con. 5's	1,500,000	..	86	88
Richmond Co., S. I.	348,650	50	50	..
" Bonds	100,000	1,000	..	..
Standard	5,000,000	100	74½	75½
Preferred	5,000,000	100	107	110
Bonds, 1st Mortgage, 5's	1,500,000	1,000	108½	110½
Yonkers	299,650	50	112	.
Out-of-Town Companies.				
Brooklyn-Union	15,000,000	100	78	79
" " Bonds (5's)	15,000,000	1,000	105	105¼
Bay State	5,000,000	50	19	24
" Income Bonds	2,000,000	1,000	..	80
Boston United Gas Co.—				
1st Series S. F. Trust	7,000,000	1,000	77½	78½
2d " " "	3,000,000	1,000	51½	53½
Buffalo Mutual	750,000	100	125	..
" Bonds	200,000	1,000	95	100
Central, San Francisco	2,000,000	..	95	..
Chicago Gas Co.	25,000,000	100	64¼	64½
Chicago Gas Lt. & Coke Co. Guaranteed Gold Bonds.	7,650,000	1,000	94	94¼
Columbus	1,000,000	..	66½	67
1st Mortgage	1,065,000	..	94	95
Consumers. Jersey City	2,000,000	100	76	80
" Bonds	600,000	1,000	102	104
Cincinnati G. & C. Co.	7,000,000	100	202	..
Consumers, Toronto	1,600,000	50	184½	187
Capital, Sacramento	500,000	50	..	41
Bonds (6's)	150,000	..	..	..
Consolidated, Baltimore	11,000,000	100	55½	56½
Mortgage, 6's	3,600,000	..	107	107½
Chesapeake, 1st 6's	1,000,000	..	..	..
Equitable, 1st 6's	910,000	..	..	..
Consolidated, 1st 5's	1,490,000	..	..	..
Detroit	4,000,000	..	..	29
" Con. Bonds	4,312,000	..	71½	75
Equitable Gas & Fuel Co., Chicago, Bonds	2,000,000	1,000	..	101
Fort Wayne	2,000,000	..	73½	75½
" Bonds	2,000,000	..	84	87
Hartford	750,000	25	..	145
Indianapolis	2,000,000	..	136	142
" Bonds, 6's	2,650,000	..	101½	105
Jersey City	750,000	20	180	..
Lafayette Gas Co., Ind.	1,000,000	100	78½	82½
Bonds	1,000,000	1,000	85½	87½
Louisville	2,570,000	50	..	130
Laclede, St. Louis	7,500,000	100	20½	20¾
Preferred	2,500,000	100	79	80
Bonds	9,084,400	1,000	93½	95¾
Little Falls, N. Y.	50,000	100	..	100
Bonds	25,000	..	..	100
Montreal, Canada	2,000,000	100	200	.
Newark, N. J., Gas Co.	1,000,000	..	93	98
Bonds, 6's	4,000,000	..	123	..
New Haven	1,000,000	25	225	..
Oakland, Cal.	2,000,000	..	46½	..
" Bonds	750,000	..	..	..
Peoples Gas Lt. & Coke Co., Chicago, 1st Mortgage	2,100,000	1,000	..	108
2d "	2,500,000	1,000	104	105
Peoples, Jersey City	500,000	50	..	175
Paterson, N. J.	.....	25	99	102
Rochester Gas & Elec. Co.	2,150,000	50	..	..
Preferred	2,150,000	50	83	..
Consolidated 5's	2,000,000	..	87½	90
San Francisco, Cal.	10,000,000	100	71½	72
St. Paul Gas Light Co.	1,500,000	100	68½	70
1st Mortgage, 6's	650,000	..	88	90
Extension, 6's	600,000	..	..	..
General Mortgage, 5's	2,400,000	..	88	90
Syracuse, N. Y.	500,000	25	..	..
Washington, D. C.	2,000,000	20	250	..
Western, Milwaukee	4,000,000	100	64	66
Bonds, 5's	3,556,000	..	87½	90
Wilmington, Del.	500,000	50	188	190

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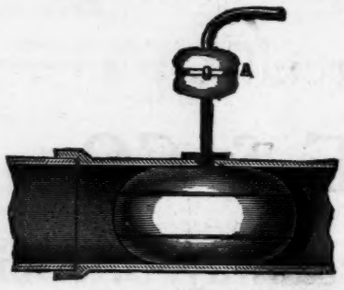

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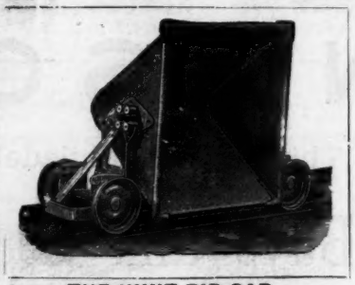

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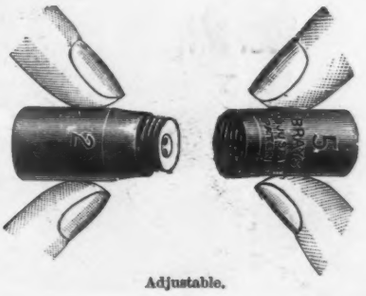

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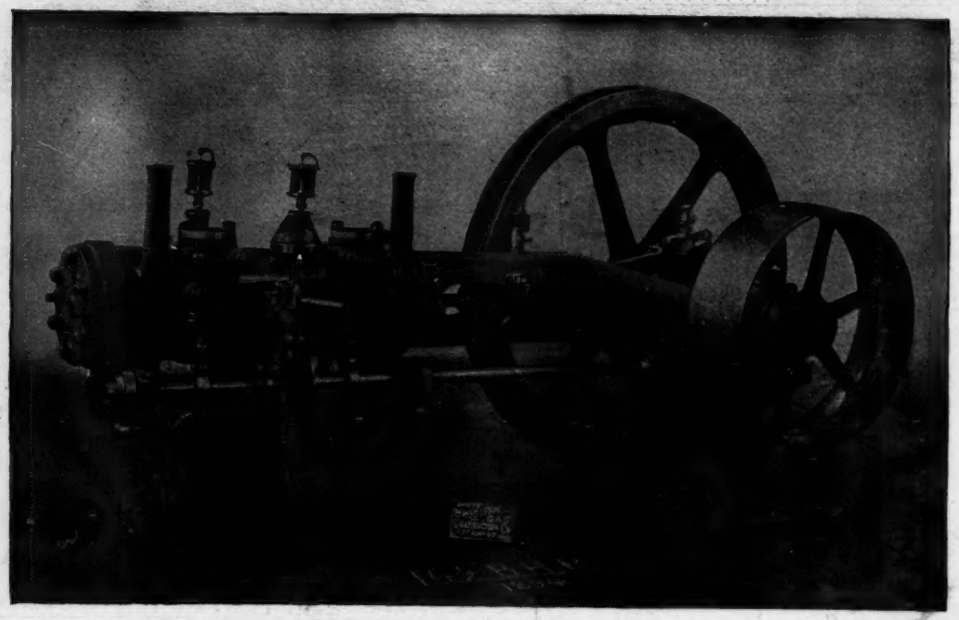

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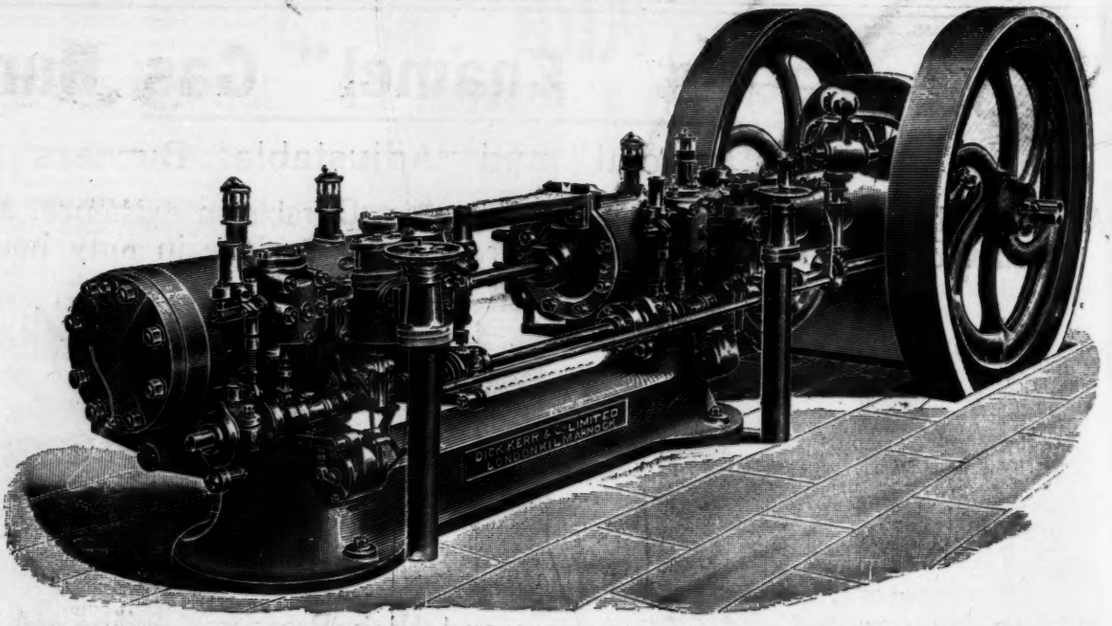

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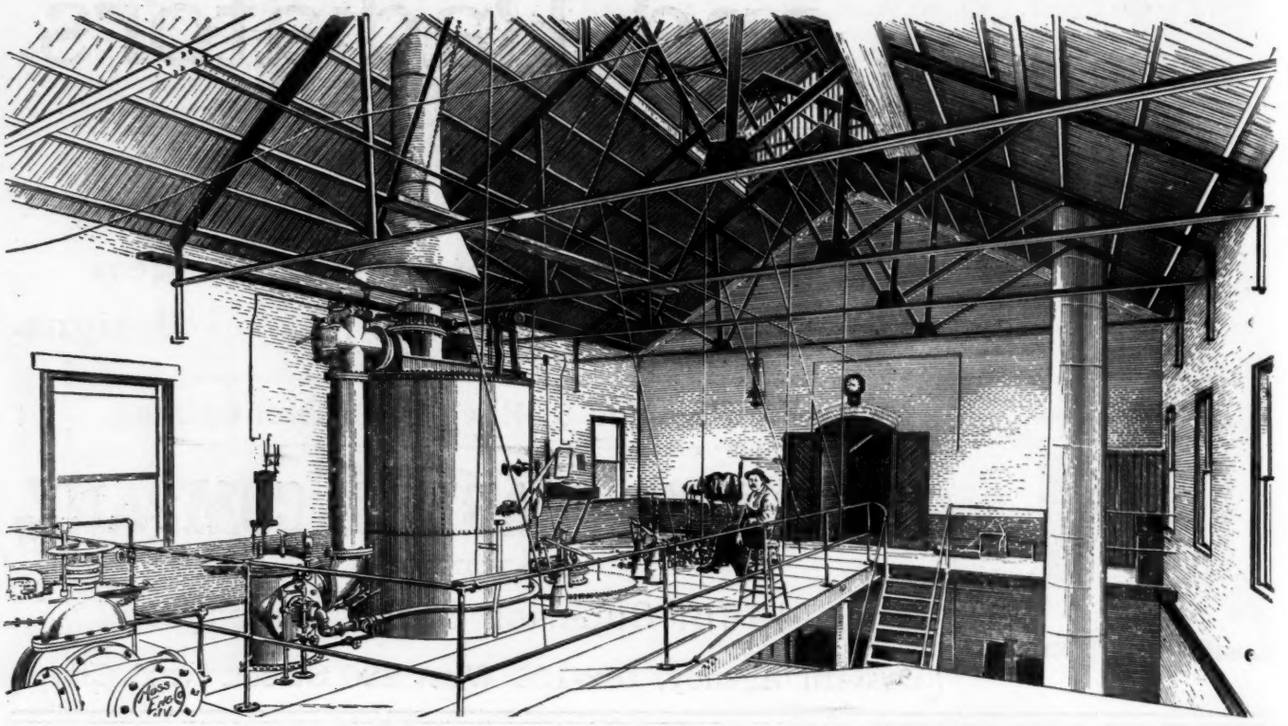

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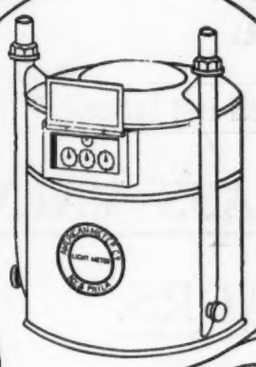

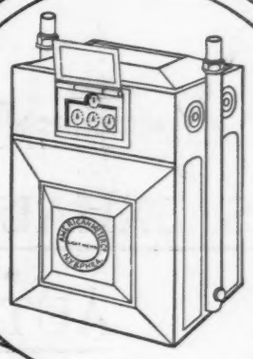

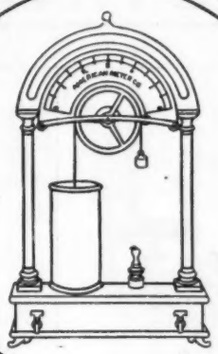

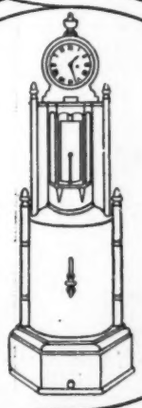

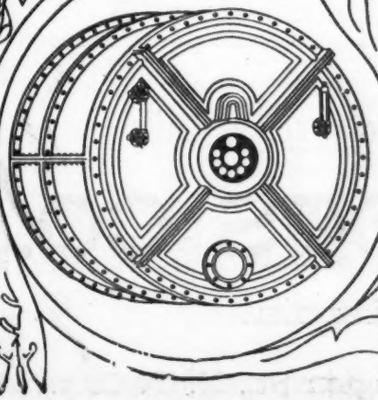

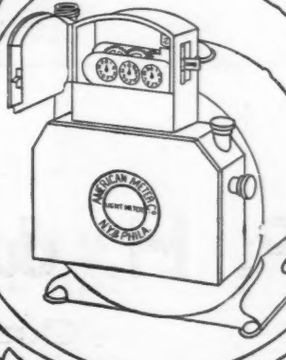

PUBLIC LIGHTING TABLE.

FEBRUARY, 1896.

Day of Week.	Date.	Table No. 1. Following the Moon. Light.	Table No. 1. Following the Moon. Extinguish.	Table No. 2. New York City. All Night Lighting. Light.	Table No. 2. New York City. All Night Lighting. Extinguish.
				P.M.	A.M.
Sat.	1	5.50 PM	9.20 PM	5.05	6.15
Sun.	2	5.50	10.40	5.05	6.15
Mon.	3	5.50	11.50	5.05	6.15
Tue.	4	5.50	1.10 AM	5.05	6.15
Wed.	5	5.50 LQ	2.20	5.10	6.10
Thu.	6	5.50	3.30	5.10	6.10
Fri.	7	5.50	4.40	5.10	6.10
Sat	8	5.50	5.40	5.10	6.10
Sun.	9	6.00	6.00	5.10	6.10
Mon.	10	6.00	6.00	5.10	6.10
Tue.	11	6.00	6.00	5.10	6.10
Wed	12	6.00	6.00	5.20	5.55
Thu.	13	6.00 NM	6.00	5.20	5.55
Fri.	14	6.00	6.00	5.20	5.55
Sat.	15	6.00	6.00	5.20	5.55
Sun.	16	6.10	5.50	5.20	5.55
Mon.	17	6.10	5.50	5.20	5.55
Tue.	18	9.40	5.50	5.20	5.55
Wed	19	10.40	5.50	5.30	5.55
Thu.	20	11.50	5.50	5.30	5.55
Fri.	21	12.50 AM FQ	5.50	5.30	5.55
Sat.	22	1.50	5.50	5.30	5.55
Sun.	23	2.50	5.40	5.30	5.55
Mon.	24	3.40	5.40	5.30	5.55
Tue.	25	4.20	5.40	5.30	5.55
Wed.	26	5.00	5.40	5.30	5.45
Thu.	27	No L.	No L.	5.30	5.45
Fri.	28	No L. FM	No L.	5.30	5.45
Sat	29	No L.	No L.	5.30	5.45

TOTAL HOURS LIGHTING DURING 1896.

By Table No. 1.	Hrs. Min	By Table No. 2.	Hrs. Min.
January	220.40	January	423.20
February	207.00	February	367.40
March	193.00	March	355.35
April	174.10	April	298.50
May	164.00	May	264.50
June	142.10	June	234.25
July	142 10	July	243.45
August	150.50	August	280.25
September	163.00	September	321.15
October	193.10	October	374.30
November	207.00	November	401.40
December	237.30	December	433.45
Total, yr.	2194.40	Total, yr.	4000.00

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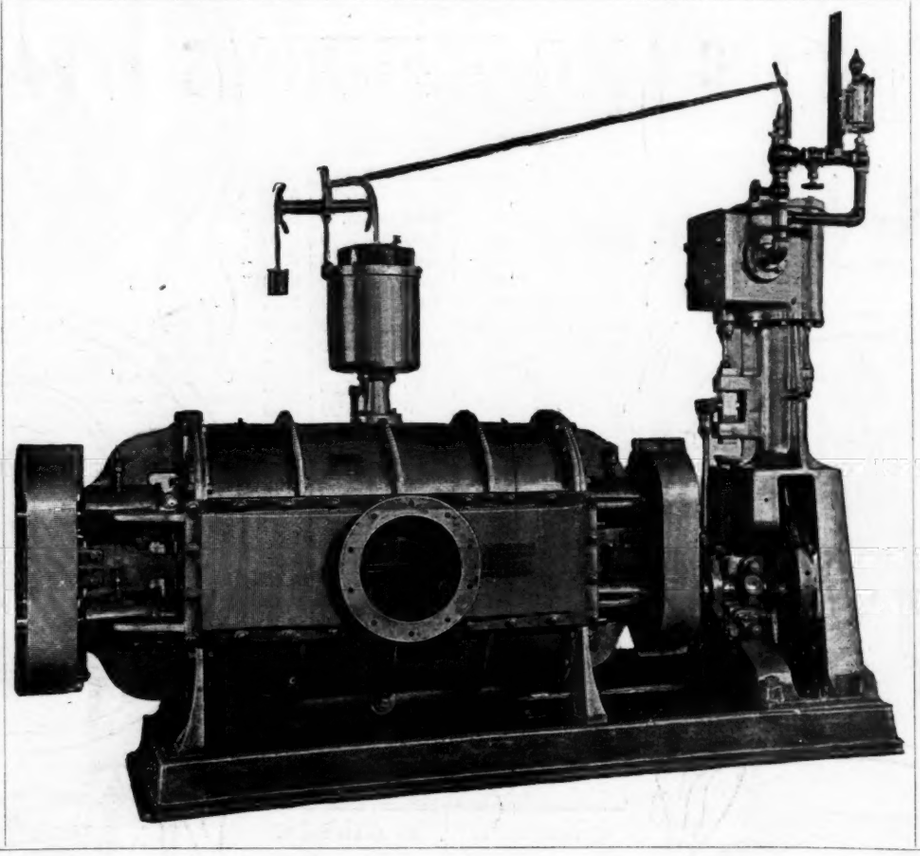

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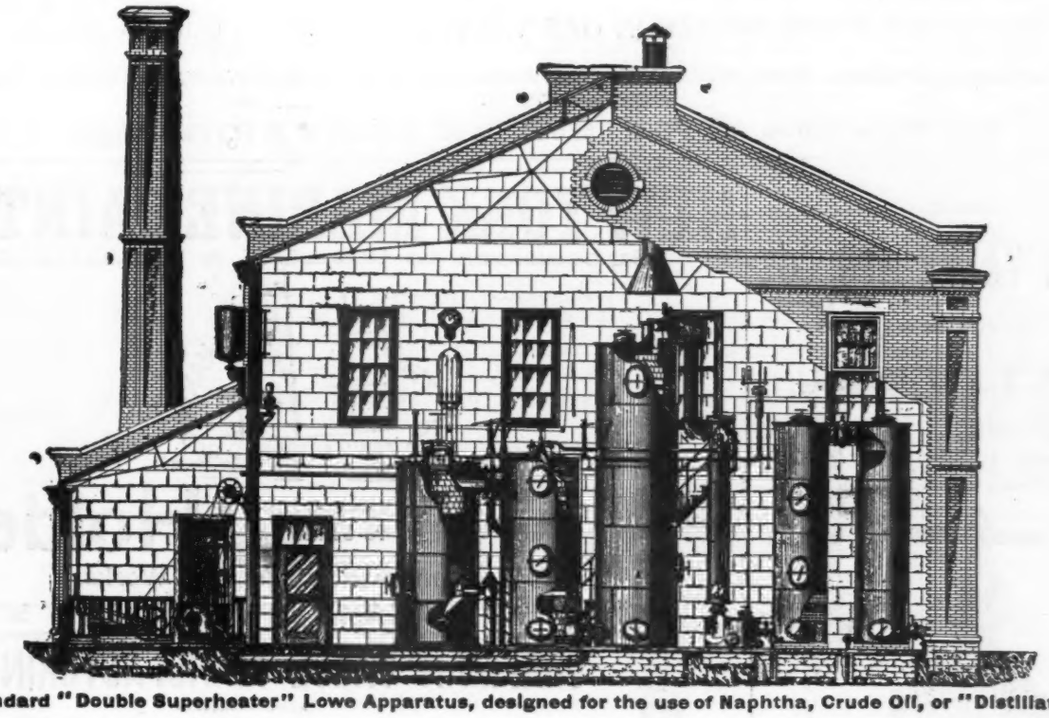

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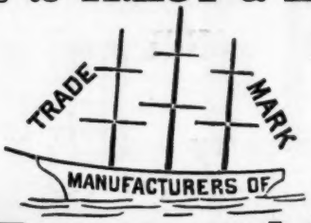

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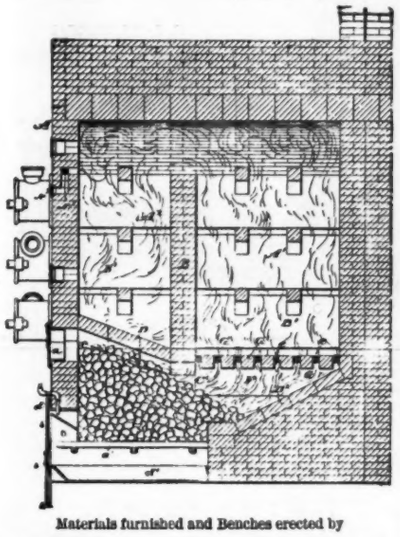

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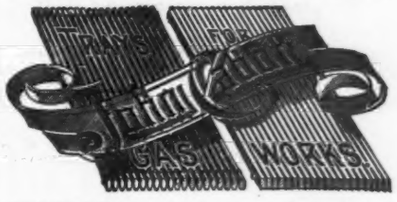

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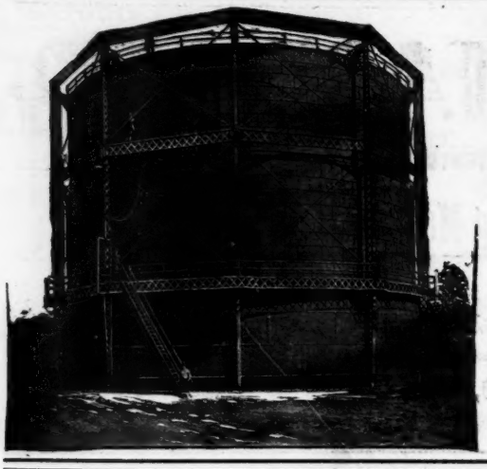

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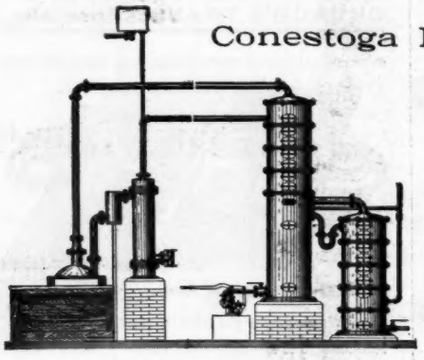

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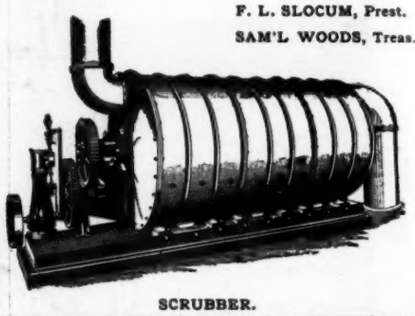

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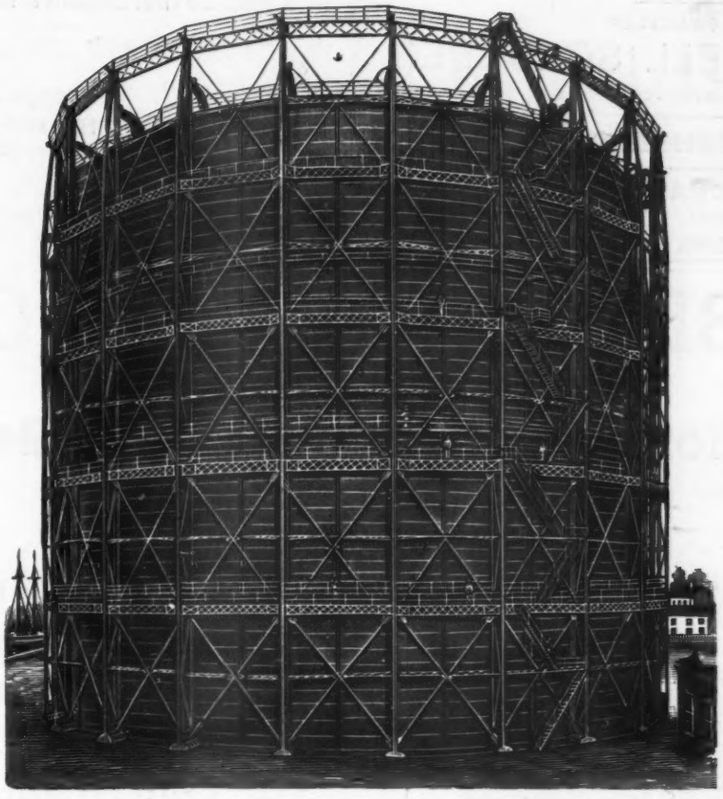

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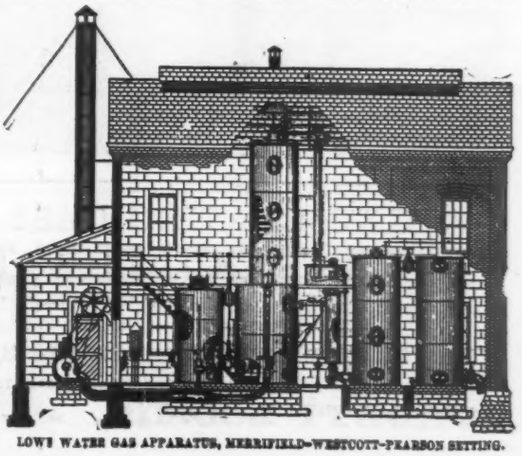

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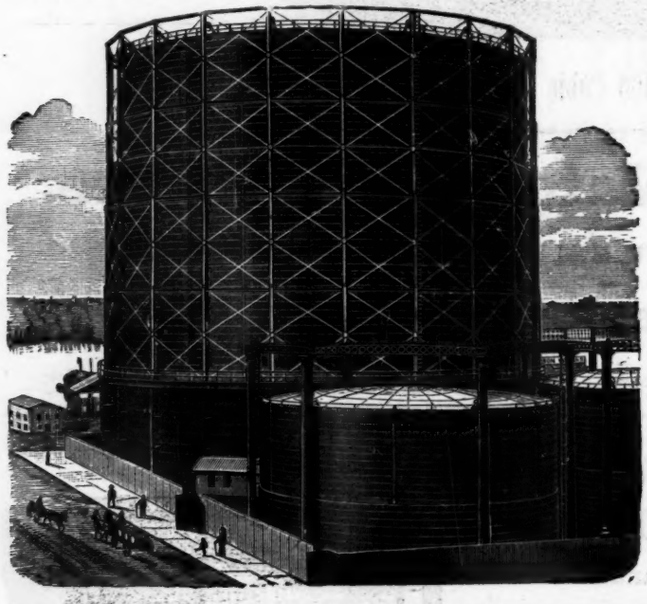

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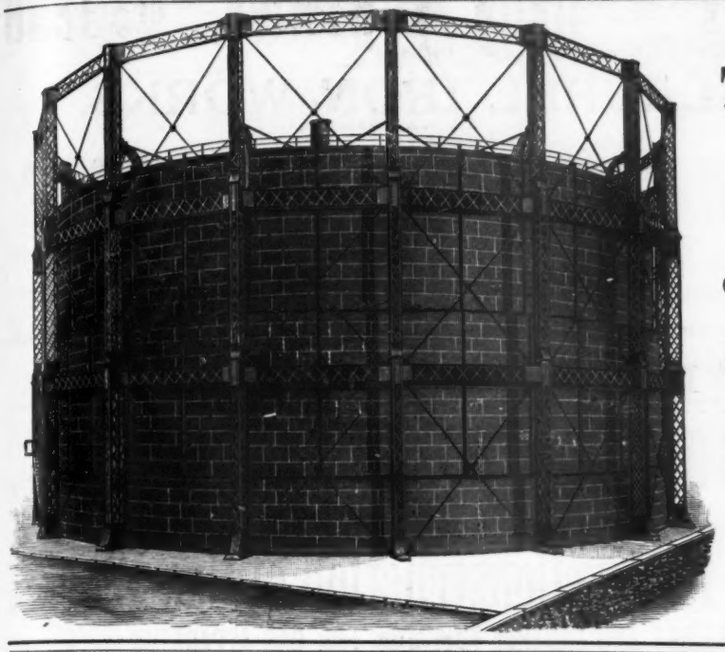

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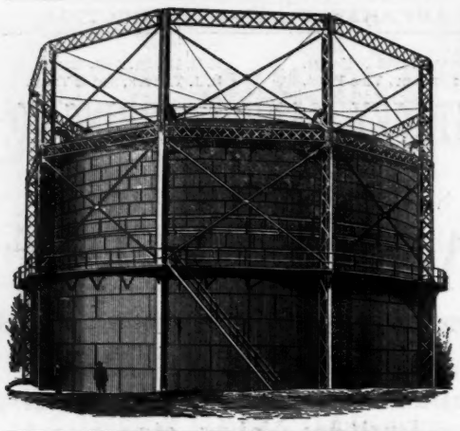

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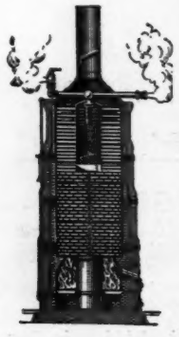

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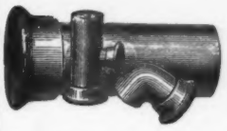
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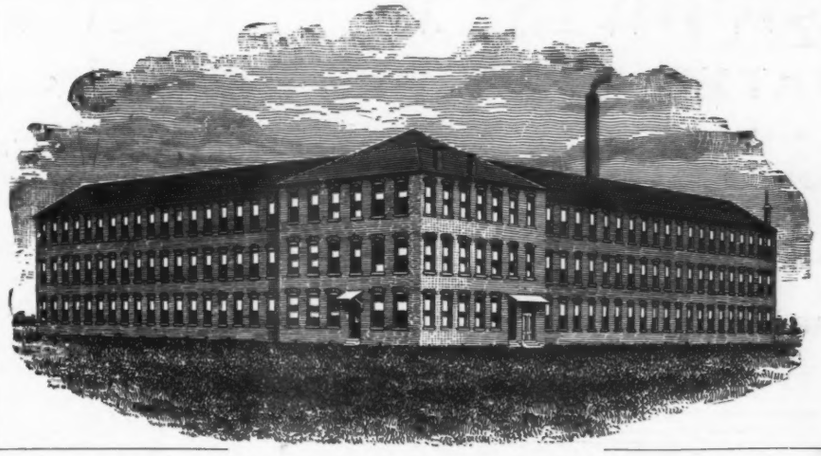

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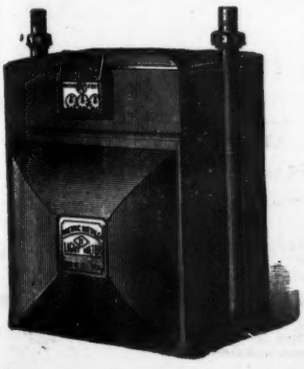
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